FILE

NORTHEAST FLOOD STUDIES

INTERIM REPORT
ON
REVIEW OF SURVEY

CONNECTICUT RIVER BASIN

MAD RIVER DAM & RESERVOIR

MAD RIVER, CONNECTICUT

Corps of Engineers, U.S. Army - Office of the Division Engineer

New England Division - Boston, Mass.

JUNE 14, 1956

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SYLLABUS

The Division Engineer finds that experienced flood losses in the Mad River Valley are sufficient to justify reservoir protection for Winsted and the downstream vicinity. He concludes that sufficient justification exists for construction of Mad River Dam above Winsted at a total estimated first cost to the United States of $5, 430, 000.

He recommends that local interests be required (1) to provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the project; and (2) to maintain the project after completion. He further recommends that this reservoir be constructed in the immediate future.

SUBJECT: Interim Report for Flood Control, Mad River Dam and Reservoir, Mad River, Farmington River Basin, Connecticut

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.
ATTENTION: ENGWF

1. AUTHORITY

This report is submitted pursuant to authority contained in a Resolution by the Committee on Public Works of the United States Senate, adopted September 14, 1955:

> "That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review previous reports on the...Connecticut River, Connecticut, Massachusetts, Vermont and New Hampshire... and intervening streams; in the area affected by the hurricane flood of August 1955, to determine the need for modification of the recommendations in such previous reports and the advisability of adopting further improvements for flood control and allied purposes in view of the heavy damages and loss of life caused by such floods."

2. SCOPE OF SURVEY

2.1 Scope. - This interim report of survey scope for the Mad River watershed is submitted in partial compliance with 1st indorsement, dated 16 September 1955, from the Chief of Engineers to letter from the Senate Public Works Committee, dated 14 September 1955, subject, "Northeastern States Hurricane Flood Study."

This report is a review of flood problems in the vicinity of Winsted, Connecticut, to determine the advisability and cost of flood-control improvements and makes specific recommendations in the interest of flood control.

2.2 Topographic Surveys. - U. S. Geological Survey and Army Map Service maps were used in the study. Surveys accomplished at the Mad River dam site consisted of field-checking these maps.

2.3 Subsurface Exploration. - Subsurface explorations and a geologic reconnaissance have been made at the dam site. Results of geologic and soils investigations are included as Appendix A.

2.4 Flood-Damage Survey. - Surveys of flood damage were made following the floods of 1938, 1948, and 1955. The surveys consisted of personal interviews with municipal and state officials, officers of industrial concerns, and private individuals suffering damages. A summary of the flood-damage studies is included in Appendix B.

2.5 Conferences with Local Interests. - Special Act No. 46, November 1955 Special Session of the Connecticut General Assembly, appointed a Farmington River Valley Flood Control Commission. Section 3 of the enabling act states that "Said commission shall study in all its aspects the problem of flood control in the Farmington river valley, including the Farmington river and tributary and adjacent streams.... shall cooperate with and correlate its efforts with federal and state agencies in the same field and shall give all possible aid to regional and municipal flood control, planning and redevelopment agencies in the Farmington valley area."

The Commission has held meetings with Federal, state, and municipal agencies and with private citizens in order to formulate a flood-control plan for the Winsted area. The Corps of Engineers has aided in the work of the Commission by furnishing technical data and assistance.

A combination of upstream reservoirs and local protective works to safeguard the Farmington River Basin was approved by vote at a public meeting of the Farmington River Valley Flood Control Commission at Winsted, Connecticut on 13 February 1956.

The city of Winsted, municipal organizations, and local interests have expressed the need for a flood-control project on Mad River upstream from Winsted. Copies of correspondence on this matter are included as Appendix C.

3. PRIOR REPORTS

3.1 Published Reports. - Flood control on the Farmington River and its tributaries has been considered in the following published reports on the Connecticut River Basin:

House Document No.	Congress	Session	Date	Remarks
412	74th	2d	1936	Survey report. Presented general plan for improvement of Connecticut River and tributaries. Recommended initial plan of 10 flood-control reservoirs in Vermont and New Hampshire.

House Document No.	Congress	Session	Date	Remarks
455	75th	2d	1937	Survey report. Proposed comprehensive plan of dikes and 20 reservoirs for flood control on the Connecticut River.
653	76th	3d	1940	First interim review report on the Connecticut River. Recommended modification of authorized project for protection by dikes and related works.
724	76th	3d	1940	Second interim review report on the Connecticut River. Recommended additional local works and 20 reservoirs for flood control with adaptations for future development of power.

3.2 Unpublished Reports. - The following unpublished report discusses flood control on Mad River for the protection of Winsted:

The Resources of the New England-New York Region (prepared by the New England-New York Inter-Agency Committee)

This study, prepared in pursuance of the directive contained in the Presidential letter of October 9, 1950, inventories the power potentialities of the survey area and submits a plan which the Committee recommended be used as a guide for the development, conservation, and use of the land, water and related resources of the region. Proposals for prevention and reduction of flood losses are also included. This report, in Chapter XXI, recommends channel improvement of Mad River to protect Winsted from moderate floods.

4. DESCRIPTION

4.1 General. - The city of Winsted is located in the lower part of the Mad River Basin in Litchfield County, Connecticut. The Mad River watershed has a maximum length (in a north-south direction) of about 7 miles, a maximum width (in a northwest-southeast direction) of approximately 6 miles, and an area of about 33.3 square miles. Mad River is the principal tributary of Still River, one of the principal tributaries of the Farmington River. It is a rapidly flowing stream.

The source of Mad River is at Spaulding Pond at about elevation 1,377 feet m.s.l. The river flows in a southeasterly direction, passing through Winsted to its confluence with Still River near the southeast edge of the city. Between the headwaters at Spaulding Pond to its confluence with Still River, Mad River falls approximately 680 feet in a distance of 9.4 miles.

4.2 Topography. - The watershed is hilly. The upper basin is characterized by swamps and ponds which give way to scattered lakes and narrow valleys in the lower portion of the basin. Rugg Brook Reservoir and Highland Lake drain into Mad River from the south; overflow from Crystal Lake drains into Highland Lake. The principal peaks bounding the watershed are Dennis Hill (1,630 feet), Pine Mountain (1,580 feet), Flagg Hill (1,530 feet), and Grant Hill (1,470 feet). Both hills and streams contain outcrops of granite schists and gneiss. The banks and beds of the streams are lined with stone, and the valleys and hills are dotted with boulders. Dense second-growth deciduous trees and brush (mostly elm, beech, maple, and sycamore) cover the hills and part of the valleys. Hemlock and fir are scattered in the area.

4.3 Tributaries. - The principal tributaries of Mad River are Indian Meadow Brook, Mill Brook, Rugg Brook, and Beckley Pond Brook. These streams are sources of high runoff during periods of intense rain or rapid snowmelt.

4.4 Geology. - The Mad River occupies a preglacial channel in a relatively deep, steep-sided, narrow valley. Soils covering bedrock, which is intermittently exposed throughout the area, are of glacial origin. These soil deposits are relatively thin, except in the vicinity of Winsted, where there is a very extensive deposit of glacial sediments consisting of unstratified, bouldery, silty sand. Bedrock (hard granite gneiss and granitized schist) occurs at the surface or at shallow depths in steeply inclined beds and masses.

4.5 Area Maps. - The Mad River and its watershed are shown on standard quadrangle sheets of the U. S. Geological Survey (1:31,680) and on standard quadrangle sheets of the Army Map Service (1:25,000). A map of the Mad River watershed is included as Plate 1 of this report. Profiles of Farmington, Still, and Mad Rivers are shown on Plate 2.

5. ECONOMIC DEVELOPMENT

5.1 Population. - Approximately 10,000 people live in the Mad River Basin. According to the United States Bureau of the Census, the population of the city of Winsted (which lies partly in the Mad River watershed) was 7,883 in 1930, 7,674 in 1940, and 8,781 in 1950. Except for Winsted, the towns and villages in the Mad River watershed are small. The population of the area is expected to increase along with the continuing expansion of industry which is taking place in Connecticut.

5.2 Transportation. - Freight and passenger service into the Mad River region are provided by a branch of the New York, New Haven & Hartford Railroad, Winsted being the northern terminus of this branch. Three bus lines and numerous truck and van lines also serve the area by means of U. S. Route 44, State Highways 8 and 183, and a net of secondary roads.

5.3 Manufacturing. - The city of Winsted is an important manufacturing center in the Mad River Valley. Approximately 75% of the working population is employed by the city's many industries, of which the largest manufacture clocks and electrical supplies and equipment. Other products manufactured in Winsted are hats, knitted goods, wire, and cable.

5.4 Water Power. - There are no hydroelectric plants in the Mad River Basin. In the Farmington River Basin there are five hydroelectric plants with an installed capacity of 13,850 kilowatts. The largest plant, at Rainbow, Connecticut, is owned by the Farmington River Power

Company and has an installed capacity of 8,000 kilowatts and a gross head of 60 feet. In addition, flow from Highland Lake in Winsted is controlled for a privately operated hydroelectric plant supplying seven factories in that city. There are no suitable undeveloped hydroelectric sites in the Mad River Basin.

5.5 Water Supply. - Rugg Brook Reservoir is the public water supply of the city of Winsted. A dam on the Mad River (about 0.5 mile above the mouth of Rugg Brook) diverts water from the river through an aqueduct to Crystal Lake from which it is taken for the city. Rugg Brook Reservoir has an area of 45 acres, and no significant storage is available for flood control.

5.6 Agriculture. - Agriculture is not an important occupation in the Mad River Basin because of the narrow river valley and the rocky and swampy character of much of the area. Principal agricultural products of the basin are hay, grain, and corn.

6. CLIMATOLOGY

6.1 Temperature. - The average annual temperature in the Farmington River watershed varies from 45°F. in the mountainous region to about 50°F. in the valley. In Norfolk, Connecticut, near the upper end of the Mad River watershed, the mean annual temperature for the 8 years of record from 1948 through 1955 is 45.2°F. The highest temperature recorded at Norfolk during 11 years of record was 93°F in 1949, 1953, and 1955; the lowest was -15°F. in 1945 and 1948. Detailed climatological data will be found in Appendix D.

6.2 Precipitation. - Mean annual precipitation over the Farmington River watershed is about 50 inches uniformly distributed throughout the year. Average annual snowfall varies from about 80 inches in the headwaters to approximately 40 inches in the lower portion of the watershed. The maximum and minimum annual precipitation of record at Peoples Ranger Station, 3 miles east of Winsted, are 65.76 inches and 38.61 inches. Additional precipitation data is given in Appendix D.

7. RUNOFF AND STREAMFLOW DATA

There are no stream-gaging stations in the Mad River Basin. However, the U. S. Geological Survey has published records for seven locations in the Farmington River watershed for various periods since 1913; conditions at these locations are believed to approximate those along the Mad River. Additional data from other sources in the Farmington River Valley has also been published by the U. S. Geological Survey. Records are generally good, except during periods of ice when they are fair. Further information on this subject is given in Appendix D.

8. MAJOR FLOODS

8.1 Floods of Record. - Six floods of record have occurred in the Farmington River Basin since 1900 - November 1927, March 1936, September 1938, December 1948, and August and October 1955. The greatest, in

August 1955 resulted from rainfall that preceded and accompanied hurricane "Diane." This rain, which varied from 8 to 18 inches over the watershed, fell on ground already saturated by rain from hurricane "Connie" during the previous week.

The largest known flow in Mad River occurred in August 1955. The estimated discharge of this flood at Winsted was 15,100 c.f.s. More detailed flood data is given in Appendix D.

8.2 Historic Floods. - Major historic floods in the Farmington River watershed date back to January 1770 and include the floods of May 1801, November 1853, May 1854, October 1869, December 1878, and March 1896. There is no reliable information on the size of these floods.

9. STANDARD PROJECT FLOOD

A standard project flood was developed for the Mad and Still Rivers to demonstrate the flood-producing potentialities of the basin and the flood-control effectiveness of the proposed dam and reservoir. The standard project flood, a flood to be exceeded only on rare occasions, was derived by standard procedures using a standard project storm and a unit hydrograph developed from an analysis of floods of record. The peak discharge of the standard project flood at the site of the proposed Mad River Reservoir is 14,700 c.f.s. At Winsted it is 23,300 c.f.s., approximately 1.5 times the August 1955 flood. Mad River Reservoir would contain the entire standard project flood except for a small discharge which would pass through the ungated outlet. It would reduce the natural peak of the standard project flood at Winsted from 23,300 c.f.s. to a peak of 9,500 c.f.s. Details of the derivation of the standard project flood are given in Appendix D.

10. EXTENT AND CHARACTER OF THE FLOODED AREA

The Mad and the Still Rivers, tributaries of the Farmington River, have caused heavy damage in the Winchester-Winsted area in past floods. Urban encroachment upon the waterways has intensified the flood problem, especially in the more thickly settled residential and business areas in the center of Winsted. The section of Main Street which runs parallel to the Mad River through the center of the city, located about 30 feet to the north and only 6 feet above the bed of the stream, has been a major damage area in each of the past floods. In this area, which extends from above Lake Street Bridge to below Case Avenue Bridge, buildings fronting the south side of Main Street are constructed wall-to-wall and are set on cantilever beams overhanging the river. In a few places the buildings span the river at levels which restrict flood flows. In the major floods of 1938, 1948, and 1955, overflow of the Mad River damaged commercial, industrial, and business properties along both sides of Main Street and has scoured out extensive sections of the highway. The flood of August 1955 demolished many structures and completely disrupted water, sewer, and other utility lines. At the same time, high stages on the Still River also caused serious losses.

The flood of 1938, the most damaging prior to the record flood of 1955, likewise caused extensive residential, commercial, and highway damage along both the Mad and Still Rivers. The 1948 flood produced less over-all damage but caused industrial losses more than three times as heavy as those of the earlier flood. The destruction caused in Winsted by the flood of August 1955 dwarfs that of other floods and resulted in seven deaths. Widespread flooding occurred throughout the full length of the Mad and Still Rivers within Winsted, bringing destruction into areas hitherto unaffected. The swift current and great depth of the flood water caused enormous urban and industrial losses, gouged out bridges and highways, and completely disrupted the transportation, power, and water-supply systems. An enormous number of structures were totally destroyed, and many were broken up and washed away. Severe flooding was also experienced along the outlet from Highland Lake to the Mad River, which was unable to carry the high discharge from the lake spillway.

11. FLOOD DAMAGES

11.1 Flood Losses. - In the flooded areas of Winsted downstream of the Mad River Dam site, the damages sustained in the flood of 1938 amounted to a total loss of $178,000; this was the heaviest experienced prior to the flood of August 1955. Losses in the flood of 1948 were less severe, amounting to about $100,000. The disastrous flood of 1955 left in its wake a total loss of over $18,000,000.

11.2 Classification of Losses. - Except for the severe flooding in the Highland Lake area, the 1955 pattern of flooding along the Mad and Still Rivers had been generally indicated in earlier floods. Much of the damage in 1955 was concentrated along the Main and North-South Main Street areas which parallel the Mad and the Still Rivers. The Mad River, swollen to record size, cut a new channel through the center of Winsted, scouring out nearly a mile of Main Street with all its utility lines to a depth of 10 to 15 feet. Not only did a majority of the stores and commercial establishments suffer complete loss of stock and equipment, but on this street alone almost 60 buildings were destroyed and about 12 of them, including two gas stations and a two-story hotel, were undermined and washed away. The town was divided when five bridges over the Mad River were washed out and another heavily damaged.

The swift flood waters of the Still River destroyed three bridges, damaged another, and caused severe urban, industrial, and highway damage. Widespread and destructive flooding occurred in the area around the confluence of the two streams. Although responsible for less than 30 percent of the total damage in Winsted, the Still River caused industrial damage as heavy as that caused by the Mad River. Of the four manufacturing concerns which sustained heavy damage from the Still River, the Gilbert Clock Company at Wallens and North Main Streets was hardest hit. The bridge, dam and powerhouse were washed away, one corner of a brick office building was scoured out, and the foundations of several other buildings were severely undermined. In addition, large areas of the company grounds were deeply eroded by the current.

11.3 Average Annual Losses. - For the purpose of economic study and comparison of benefits to cost, estimates of recurring flood losses have been converted to an annual basis. The average annual loss in the Winsted area along the Mad and Still Rivers below the Mad River Reservoir site is estimated at $327,000. This amount is conservative, as annual flood losses that have occurred below the confluence of Sandy Brook and Still River have not been evaluated and are not included. The estimates of annual losses have been derived in accordance with the Corps of Engineers' standard practice of correlating stage-damage, stage-discharge, damage-discharge, discharge-frequency, and damage-frequency relationships.

Appendix B contains detailed description of analysis of damage surveys, loss summaries, and annual losses and benefits.

12. EXISTING CORPS OF ENGINEERS' FLOOD-CONTROL PROJECT

A channel-improvement project on Mad River in the city of Winsted was constructed by the Corps of Engineers between May 1950 and October 1951. This project, a unit of the comprehensive plan for flood control and other purposes in the Connecticut River Basin, was authorized by the Flood Control Act approved August 18, 1941. The work consisted of removing an abandoned dam and excavating an improved channel for 4,800 feet from Lake Street to a point approximately 1,600 feet below the

Case Avenue Bridge. The improved channel was designed for a capacity of 5,000 c.f.s., allowing a minimum freeboard of 2 feet below the profile of Main Street which parallels Mad River. The city of Winsted provided the lands and damages and operates and maintains the project. The city has fully complied with the requirements of local cooperation.

The estimated cost of this project is $172,000 for construction and $30,000 for lands and damages. However, exact construction costs cannot be determined until settlement has been made with the bonding company which is surety for a defaulting construction contractor.

13. IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

There are no existing non-Federal flood-control improvements in the Mad River Basin although there are river improvements for other purposes.

14. IMPROVEMENTS DESIRED

The Farmington River Valley Flood Control Commission has held several open meetings to examine flood-control desires and needs in the Farmington River Basin. As a result of these meetings and after coordination with technical advisory groups and Federal, state, and local agencies, organized groups, business concerns, and individuals have urged the immediate construction of Mad River Dam and Reservoir for the protection of Winsted. Copies of communications in regard to flood-control works are included in Appendix C. Representatives of the Corps of Engineers participated in the meetings held by the Commission.

15. FLOOD PROBLEMS AND SOLUTIONS CONSIDERED

15.1 Flood Problems. - The flood problems of Mad River are confined principally to the city of Winsted area. They were forcefully emphasized by the disastrous flood of August 1955, which had an estimated discharge in Mad River of 15,100 c.f.s., greatly exceeding the capacity of the stream channel through Winsted, which has a bank-full capacity of about 5,000 c.f.s. This flood resulted primarily from (1) intensive rainfall in the upper watershed upon ground saturated by an earlier storm; (2) inherently poor channel hydraulics; and (3) insufficient natural valley storage in the upstream reaches.

The channel through the city is restricted by buildings, walls, and bridges. These structures permitted formation of some debris dams with resulting increase in flood levels. The depth of over-bank flooding, the concentration of flow, and the steep hydraulic characteristics of the flooded area produced damaging flood velocities.

Prevention of similar flooding in the future will require adequate regulation to maintain a flow consistent with the capacity of the channel. Control of high flood peaks and excessive channel velocities through Winsted is required for adequate regulation of Mad River.

15.2 <u>Solutions Considered.</u> - Several methods and combinations of methods for protection against damaging floods of the Mad River were considered as part of this study. Among these methods was a plan to utilize Highland Lake for flood storage. This plan was found impracticable because the lake is kept full for water supply and hydropower purposes and enlargement for flood control storage would require the acquisition of costly real estate and entail expensive construction. A program to further deepen, straighten, and widen the already improved channel of Mad River through Winsted was also considered. In some reaches of the river, this would require the removal and replacement of existing retaining walls, expensive underpinning of buildings and walls, and the construction of dikes and flood walls. The excessive cost and dislocation necessitated by such work precluded it from further consideration.

Provision of adequate upstream storage is one practical way to protect Winsted against floods, but there are few suitable reservoir sites on the tributaries of the Mad River. Construction of the numerous small dams on the Mad River and tributaries that would be required to protect Winsted from flood damage would be far more expensive than the construction of a single dam for the same purpose. Construction of one dam on the Mad River, as described in the following paragraphs, appears to be the most practical method of providing necessary upstream storage for regulation of flood stages through Winsted.

16. FLOOD-CONTROL PLAN

16.1 General. - The improvement considered most desirable and feasible for the Mad River Basin is a dam and reservoir on the Mad River. The site of the Mad River Dam is located in the town of Winchester, Connecticut, about 2.2 miles above the confluence with the Still River and about 0.3 mile northwest of the city of Winsted. The reservoir would lie entirely within the limits of the town of Winchester. The total drainage area of Mad River is 33.3 square miles; the drainage area above the dam site is 18.2 square miles. The project would consist of a rolled earth-fill dam (168 feet high, about 1,040 feet long) across the Mad River and two dikes across saddles located on the left bank north of the dam. A side-channel spillway would be located at the northerly end of the dam. The capacity of the reservoir at spillway-crest elevation of 973 feet, mean sea level, would be 9,630 acre-feet, equivalent to 10 inches of runoff from the tributary drainage area.

The project would require acquisition of approximately 282 acres of land, 46 buildings, and relocation of about 2.3 miles of U. S. highway and 2.3 miles of utilities along this highway.

A cost estimate of the principal features of this project is shown in Table I. Details of this project, together with a reservoir map and general plan and details of the dam, are given in Appendix E.

16.2 Spillway Design Flood. - The peak of the spillway design flood would be 38,600 c.f.s., equivalent to 2,120 c.f.s. per square mile from the tributary drainage area. The resulting spillway design discharge would be practically equal to the maximum reservoir inflow and would produce a spillway surcharge of 12.2 feet. It is proposed to provide a spillway with a freeboard of 2.8 feet, bringing the top of dam to elevation 988 m.s.l., which is 15 feet above spillway crest. Additional data is given in Appendix D.

16.3 Outlet. - The outlet would consist of a single ungated 48-inch concrete conduit discharging into Mad River through a concrete stilling basin. The upstream end of the conduit would contain a trash rack to prevent clogging of the sluice. Flood flows exceeding the capacity of the conduit would be stored in the reservoir. The size of the conduit would permit passage of the normal flow of the river without appreciable storage in the reservoir. When the reservoir was full, the discharge through the conduit would be approximately equal to the capacity of the downstream channel. Detail hydrologic studies in connection with the design of the project may show that a gated conduit will be necessary to prevent an increase in flood damage at downstream communities along the Connecticut River.

17. MULTIPLE-PURPOSE FEATURES

The Federal Power Commission has stated informally that neither installation of power facilities nor provision for a conservation pool for downstream uses are warranted at the Mad River Dam and Reservoir site.

18. RECREATIONAL DEVELOPMENTS

The Mad River watershed is characterized by wooded hills, swampy lowlands, steep valleys, and a few ponds and lakes. Except for Winsted, the single urban center in the area, the greater part of the basin is undeveloped. The only formally designated recreation spot is Dennis Hill State Park in the headwater region.

In contrast to the other lakes in the basin, Highland Lake, which is partially within the city limits of Winsted, is large enough for boating as well as swimming; fishing is reported to be fair to poor. Crystal Lake and Rugg Brook Reservoir are not available for recreation because they are a public water supply (although the surrounding second- and third-growth forest cover afford excellent opportunities for picnicking, camping, hiking, and hunting). Likewise, the rapidly-descending Mad River itself is unsuited to water sports other than fishing, and the steep valleys and swampy lowlands of the river are of small recreational value.

Since the proposed Mad River Reservoir will be empty except during periods of heavy runoff, it will not change the recreation potential of the area. Consideration has been given to the maintenance of a small pool for recreational or esthetic purposes, but local interests have indicated a preference for a "dry" dam to be used only for flood-control purposes. A preliminary report by the U. S. Fish and Wildlife Service concurring in construction of the proposed dry dam is included as Exhibit 3, Appendix C.

19. ESTIMATES OF FIRST COST AND ANNUAL CHARGES

Estimates have been prepared on the basis of provisions of existing Flood Control Acts except that local interests would be required to provide all lands and rights-of-way necessary for the construction and operation of the project and to maintain the project after its completion. Unit prices used in estimating costs are based upon actual bids received for similar work in the same general area revised to 1956 price levels. Annual charges are based on an interest rate of 2.5% with amortization of the project cost to be distributed over a 50-year period.

The estimated Federal first cost for the proposed project is $5,430,000 with the Federal annual charges estimated at $196,000. Non-Federal first costs for lands, easements, and rights-of-way are estimated at $390,000 with annual charges of $16,000, including tax losses estimated to be $1,000. The total project first cost is $5,820,000 and the total project annual charges are $212,000. A summary of the first costs and annual charges for the project is shown in Table I. Detailed costs are shown in Table E-1, Appendix E.

TABLE I

FIRST COSTS AND ANNUAL CHARGES

MAD RIVER DAM AND RESERVOIR
(1956 Price Level)

FEDERAL INVESTMENT		
Relocations	$ 954,000	
Reservoir	4,000	
Access Road	12,000	
Dam	3,650,000	
Engineering and Design	440,000	
Supervision and Inspection	370,000	
Total Federal First Cost	$5,430,000	
Interest During Construction	140,000	
Total Federal Investment		$5,570,000
NON-FEDERAL INVESTMENT		
Lands, Easements, and Rights-of-Way	$ 390,000	
Total Non-Federal First Cost	$ 390,000	
Interest During Construction	10,000	
Total Non-Federal Investment		400,000
Total Project Investment		$5,970,000
FEDERAL ANNUAL CHARGES		
Interest on Federal Investment	$ 139,000	
Amortization	57,000	
Total Federal Annual Charges		$ 196,000
NON-FEDERAL ANNUAL CHARGES		
Interest on Non-Federal Investment	$ 10,000	
Amortization	4,000	
Net Loss of Taxes	1,000	
Maintenance	1,000	
Total Non-Federal Annual Charges		16,000
Total Project Annual Charges		$ 212,000

20. ESTIMATE OF BENEFITS

The operation of Mad River Dam and Reservoir would reduce flood damages in reaches of the Mad and Still Rivers downstream from the project to the confluence of Still River and Sandy Brook. Computed project benefits are based on the differences between losses under present conditions and losses estimated for conditions after completion of the project. Average annual benefits are estimated at $263,000 at 1956 price levels.

21. COMPARISON OF BENEFITS AND COSTS

The total annual benefits from the proposed project are $263,000 and the total annual charges are $212,000. The ratio of benefits to cost is 1.2 to 1.

22. PROPOSED LOCAL COOPERATION

The reduction of flood damages attributable to the proposed reservoir would be largely in the city of Winsted; lesser reductions would be effected at Riverton and at other downstream locations along the Still River. The reservoir, therefore, would act as a local protective project for which, under existing flood-control law, local contribution is required. Even though the proposed reservoir would exercise some general flood-control effect, local interests should participate to a certain extent in the costs of the project.

However, in arriving at an equitable sharing of the cost for the reservoir, consideration was given to the fact that the city of Winsted suffered exceptionally heavy damages during the 1955 flood and that local interests have already expended substantial amounts for land acquisition, removal of buildings, and channel enlargement in an effort to improve the floodway through the city. It was concluded that a reasonable approach to apportioning the cost would be to require non-Federal interests to provide all lands and rights-of-way necessary for construction and operation of the project and to maintain the project after completion.

The city of Winsted and other local interests which would be benefited by the proposed project have supported and urged the need for the reservoir but questioned their ability to participate in the cost of the work. The Governor of Connecticut, however, has advised this office of the interest of the State in the proposal. He has stated informally that he is prepared to ask the Legislature for funds for this purpose should such participation be required under the authorizing legislation.

23. COORDINATION WITH OTHER AGENCIES

It is the established policy of the Corps of Engineers to coordinate with Federal and state agencies and local organizations which have interests in projects under study. The Federal agencies contacted in regard to the construction of Mad River Dam and Reservoir are the Department of Health, Welfare and Education; Fish and Wildlife Service, and

Federal Power Commission. Letters from the Fish and Wildlife Service and the Federal Power Commission concurring in the projects are included in Appendix C. The Federal agencies contacted have been requested to conduct studies and to submit recommendations which will be considered in the over-all dam and reservoir plan. Interested state and local agencies in the area have also been contacted and asked for their comments on the projects. Letters from the Winchester Flood and Erosion Control Board and the Connecticut State Flood Control and Water Policy Commission are included in Appendix C. This project does not conflict with the over-all basin plan as recommended in the report on "Resources of the New England-New York Region" prepared by the New England-New York Inter-Agency Committee.

24. DISCUSSION

24.1 Need. - Flood control is urgently needed for the protection of Winsted and downstream areas. Six major floods have occurred in the Mad River Basin since 1900. In the most disastrous of these floods - that of August 1955 - seven lives were lost, almost a mile of Winsted's Main Street was gouged out to a depth of 10 to 15 feet, about 60 buildings were destroyed, five bridges over Mad River were washed out and another was badly damaged, and a majority of the stores and commercial establishments along Main Street suffered a complete loss of stock. Industrial, commercial, and residential property damages were extremely large. Without adequate flood control of the

Mad River, it is probable that a disaster similar to that of 1955 will be repeated.

24.2 Plan of Improvement. - The most feasible plan for flood protection of Winsted and the immediate downstream areas is construction of a flood-control reservoir on Mad River. Further studies may indicate that this construction should be augmented by a limited amount of diking, floodwalls, channel re-alignment, and dredging in certain developed areas along the Mad and Still Rivers to supplement work now being accomplished. These possible flood-protection works will be considered in a forthcoming report. This interim report is limited to consideration of the pressing need for a flood-control dam and reservoir on Mad River. Benefits to be realized from operation of this reservoir are estimated to be $263,000 annually.

25. CONCLUSIONS

It is concluded that the Mad River flood-control project is economically justified. Benefits attributable to the project exceed the costs in a ratio of 1.2 to 1. The frequency of major storms, the rapid growth of the area, and the existing high industrial concentration make immediate construction of the project imperative.

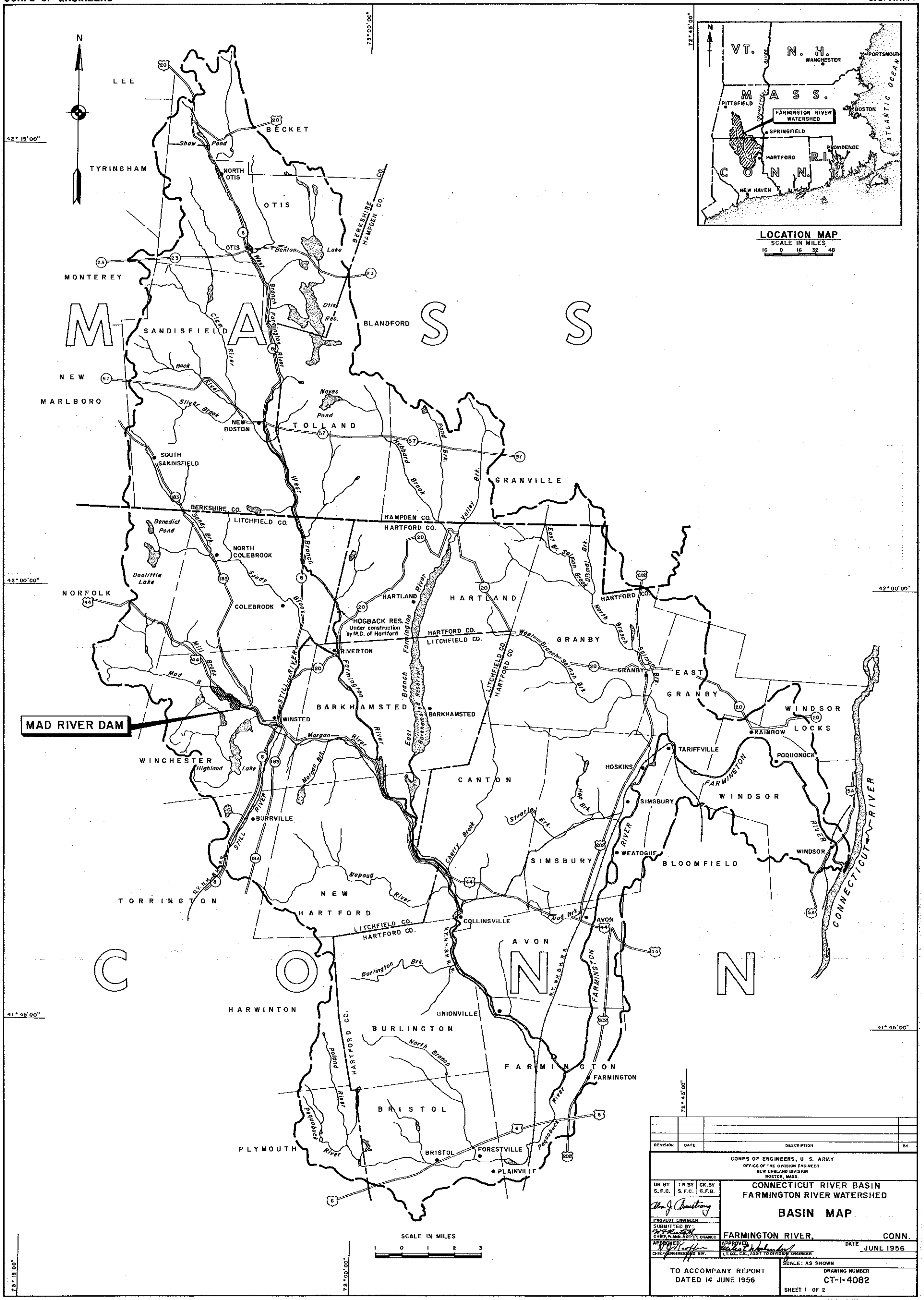
26. RECOMMENDATIONS

It is recommended that the plan for the control of floods in the Connecticut River basin approved by the Act of June 22, 1936 (Public Law

No. 738, 74th Congress) as amended and supplemented be modified to provide for the construction of a flood-control reservoir on the Mad River above Winsted, Connecticut at an estimated first cost to the United States of $5,430,000.

ROBERT J. FLEMING, JR.
Brigadier General, U. S. Army
Division Engineer

7 Inclosures
1. Plate 1
2. Plate 2
3. Appendix A w/2 Plates
4. Appendix B w/1 Plate
5. Appendix C
6. Appendix D w/4 Plates
7. Appendix E w/2 Plates



REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

CONNECTICUT RIVER BASIN
FARMINGTON RIVER WATERSHED

BASIN MAP

FARMINGTON RIVER, CONN.

DR. BY S.F.C. | TR. BY S.F.C. | CK. BY G.F.B.

PROJECT ENGINEER
SUBMITTED BY:
CHIEF, PLANN. & RPTS. BRANCH
APPROVED:
CHIEF, ENGINEERING DIV.
APPROVED:
LT. COL., C.E., ASST. TO DIVISION ENGINEER

DATE JUNE 1956
SCALE: AS SHOWN
DRAWING NUMBER CT-1-4082
SHEET 1 OF 2

TO ACCOMPANY REPORT DATED 14 JUNE 1956

PLATE NO. I

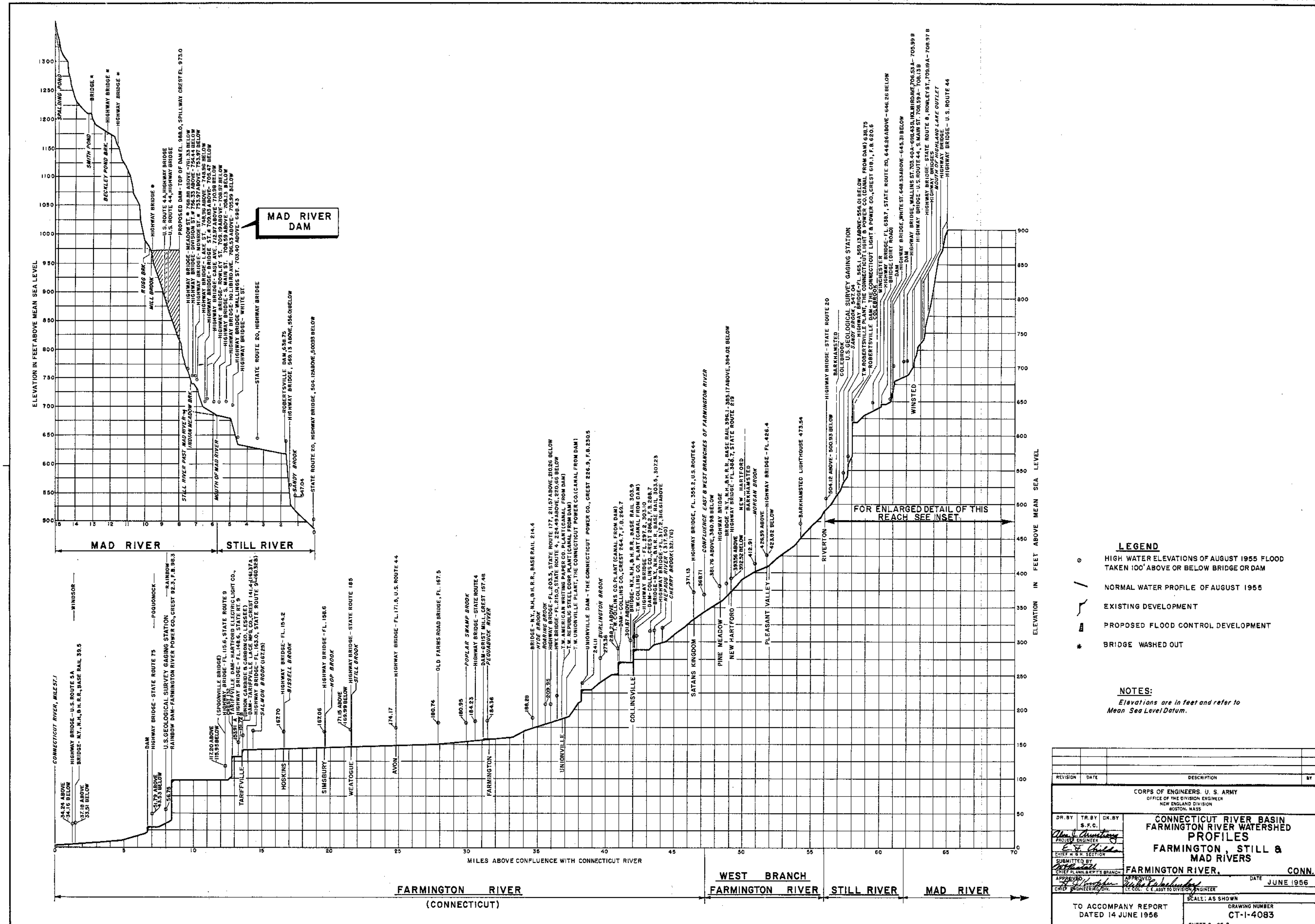

MAD RIVER DAM
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
MAD RIVER
STILL RIVER
FOR ENLARGED DETAIL OF THIS REACH SEE INSET
LEGEND
HIGH WATER ELEVATIONS OF AUGUST 1955 FLOOD TAKEN 100' ABOVE OR BELOW BRIDGE OR DAM
NORMAL WATER PROFILE OF AUGUST 1955
EXISTING DEVELOPMENT
PROPOSED FLOOD CONTROL DEVELOPMENT
BRIDGE WASHED OUT
NOTES:
Elevations are in feet and refer to Mean Sea Level Datum.
TARIFFVILLE
HOSKINS
SIMSBURY
WEATOGUE
AVON
FARMINGTON
UNIONVILLE
COLLINSVILLE
SATANS KINGDOM
PINE MEADOW
NEW HARTFORD
PLEASANT VALLEY
RIVERTON
WINSTED
MILES ABOVE CONFLUENCE WITH CONNECTICUT RIVER
FARMINGTON RIVER
(CONNECTICUT)
WEST BRANCH FARMINGTON RIVER
STILL RIVER
MAD RIVER
CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.
CONNECTICUT RIVER BASIN
FARMINGTON RIVER WATERSHED
PROFILES
FARMINGTON, STILL & MAD RIVERS
FARMINGTON RIVER, CONN.
JUNE 1956
SCALE: AS SHOWN
TO ACCOMPANY REPORT DATED 14 JUNE 1956
DRAWING NUMBER CT-1-4083
SHEET 2 OF 2

PLATE NO. 2

APPENDIX A

GEOLOGY

APPENDIX A

GEOLOGY

TABLE OF CONTENTS

APPENDIX A

GEOLOGY

A1. GEOLOGY AND TOPOGRAPHY

A1.1 Regional Geology and Topography. - The relatively small drainage area of the Mad River lies entirely within the highland region of northwestern Connecticut, although the preglacial drainage of this area was completely different from the present drainage pattern. Winsted is located on a large deposit of glacial sediments which fills the preglacial valley of the upper reaches of the Naugatuck River. (The Still River occupies this deeply filled older valley.) Above the glacial dam at Winsted, the Mad River occupies its preglacial channel in a relatively deep, steep-sided and narrow valley. Nearby valleys are of comparable ruggedness. The summits of ridges and hills, reaching to several hundred feet above the bottom of the valleys, have been rounded and eroded by glacial scour. The soils covering bedrock, which is intermittently exposed throughout the area, are of glacial origin. On the higher ground, these soil deposits are relatively thin and consist of unstratified and bouldery silty sand. Stratified sandy and gravelly materials of glacial-stream deposition occur only in minor amounts except near Winsted, where the extensive glacial deposit mentioned above is found.

The bedrock formation consists of several crystalline rock varieties, long recognized and named Becket Gneiss. It is a very old formation, probably pre-Paleozoic, and the oldest formation of the area. Numerous rock types, ranging from granite to schist, occur in steeply inclined beds and masses. The general trend of strata is north and northeasterly.

A1.2 Location and Description of Site. - The Mad River Dam site is located on the Mad River, approximately 0.3 mile upstream from the westerly limits of Winsted, and about 2.2 miles above the confluence of the Mad and Still Rivers. U. S. Route 44, a concrete highway and a main thoroughfare, passes through the site.

At the site, the Mad River flows in a characteristically narrow, steep-sided valley. Bedrock (hard granite gneiss and granitized schist) occurs at the surface or at shallow depth throughout the steep left abutment. Route 44 passes through this abutment in a rock cut 25 to 40 feet deep. Bedrock occurs in the stream bed and, it is judged, occurs at shallow depth in the right abutment. (This is not certain, but the steepness of slope indicates bedrock or a very stable glacial formation.)

Two low areas occur in the higher ground of the reservoir rim, upstream of the left abutment. One of these, a small saddle at about elevation 963, will require an earth dike. Farther upstream a larger saddle at about elevation 943 will require a considerably larger dike. With bedrock either at, or near, the surface throughout the left abutment a cutoff wall can be constructed at relatively little cost. The need for a cutoff wall beneath the two dikes is doubtful, but this condition and the one at the right abutment require further study.

The spillway for an earthen dam, which at this stage appears to be the least expensive structure, will be located in the left abutment. The topography indicates that a side-channel spillway is the most feasible.

A1.3 Geologic Investigations. - A geological reconnaissance of the site was made to appraise general foundation conditions; to review the necessity for, and location of, subsurface exploration; and to evaluate the problem of construction materials.

Foundation explorations consisting of eight test borings (Plate A-1) have been completed. Drive samples of overburden and rock cores were obtained at all these borings. Overburden samples and cores have been classified, the former in accordance with the Unified Soils Classification System (Plate A-2).

A2. FOUNDATION CONDITIONS

A2.1 Overburden. - Because of the thinness of soil covering the bedrock in the left abutment area, the overburden is of secondary consideration. It is of more importance in the higher ground, where two earthen dikes must be constructed across low areas. Here the dike foundations are of stratified sand deposits of glacial-stream origin.

A2.2 Bedrock. - Hard crystalline rock occurs along the river channel, both upstream and downstream from the proposed centerline of the dam. As stated previously, scattered outcrops occur throughout the left abutment. Whereas the right abutment is a continuous steep slope from river level (elevation 815 ±) to summit of ridge (elevation 1,260), the high left abutment is an intermediate sloping rock bench at approximately elevation 950, with occasional higher ground up to about elevation 1,000.

The bedrock is a gneiss of extreme complexity comprised of an assemblage of rock types varying from schist to granite. Although some original constituent beds may have been of sedimentary origin, they are completely metamorphosed and thoroughly crystalline. The whole formation represents a rock of very considerable hardness and great structural strength.

A2.3 Ground Water. - Levels of subsurface water as indicated by observations in borings during drilling operations on the left abutment at the dam site and Dike 1 are generally at considerable depths below the rock surface. Excavations in rock in these areas, however, will probably encounter water at relatively shallow depths in water-filled joints, fissures, or local troughs. On the right abutment at the dam site, levels of subsurface water are probably shallow. In the vicinity of Dike 2, levels of subsurface water are generally less than 10 feet in depth.

A2.4 Leakage Conditions in Reservoir. - The high valley walls which completely enclose the reservoir are wide bedrock ridges except for the high ground immediately upstream of the left abutment. There is no possibility of leakage where the reservoir rim is higher than the proposed level of reservoir. Corrective measures can be taken to prevent seepage beneath the dikes on the left abutment, but this is of doubtful necessity.

A3. CONSTRUCTION MATERIALS

A3.1 Embankment Materials. - Locating permeable and impermeable sediments for construction of the main dam and the two dikes is a major problem. Its solution will require a much greater and more detailed investigation than has so far been possible. Certain factors presently recognized are:

(1) Pervious sands and gravels of bouldery content are largely located in the valley bottom. They form low terraces and are of relatively small area. Below these terraces are other bouldery deposits of sand and gravel, occurring mostly below the valley floor, river level, and water table. The boulder content of all these deposits is high, possibly up to 50 percent. Any plan to use these materials would have to provide for separation by grizzly of large cobbles and boulders from the sod, gravel, and small cobbles.

(2) Glacial till would normally be expected to occur in the valley in sufficient quantity for impervious embankment construction; that it does occur, however, is not certain. To find

such materials in sufficient quantity will require a very considerable amount of exploration by means of test pits and borings.

A3.2 Rockfill and Riprap. - All rock from required excavations, particularly the spillway, is suitable for use as rockfill or riprap. If needed, additional rock could be secured from quarries opened at outcrop areas in the reservoir.

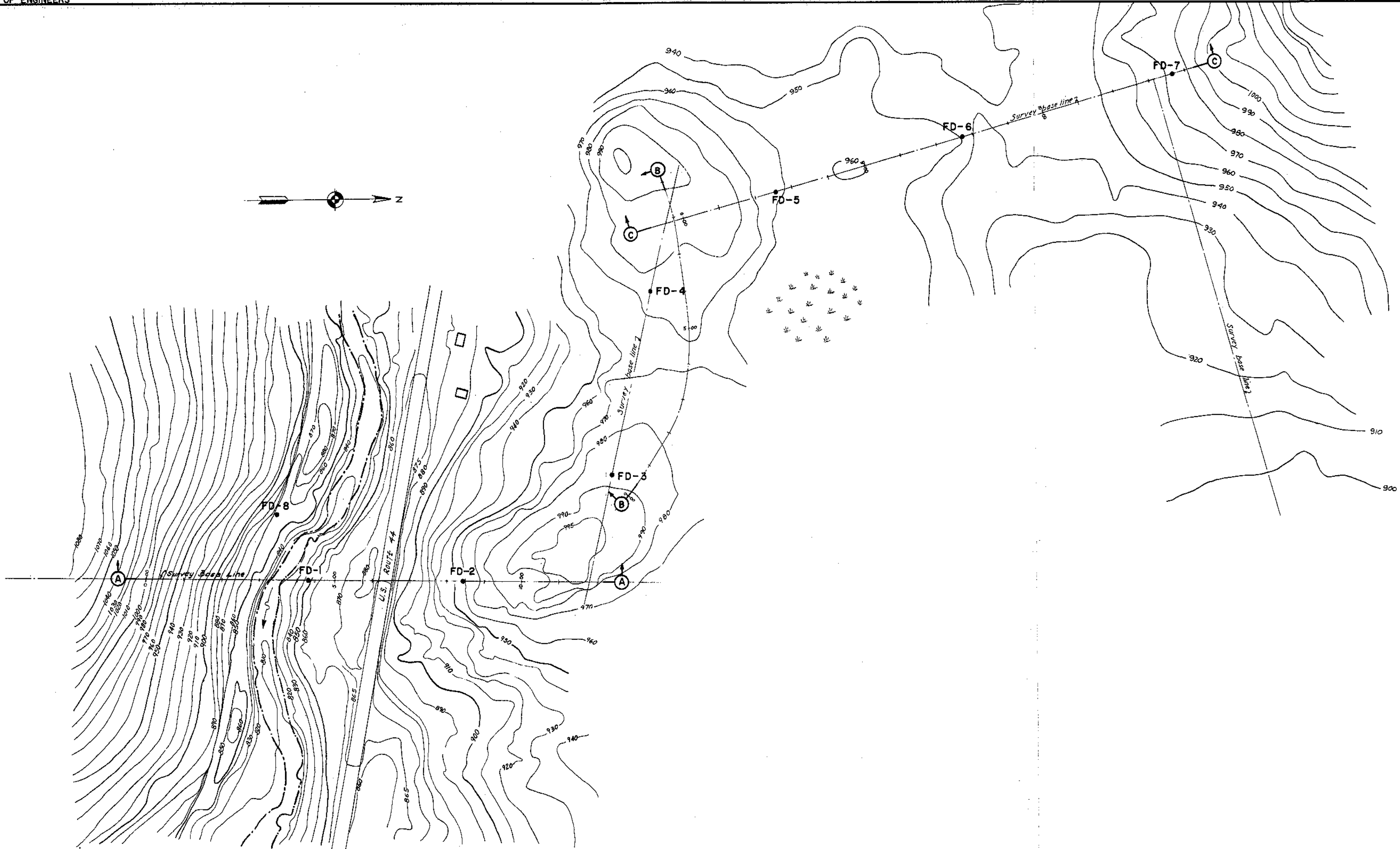
A3.3 Concrete Aggregates. - There are several established producers of commercial aggregates within economical hauling distance of the dam site. Therefore there is no need to manufacture the aggregates at the site of the work.

A4. CONCLUSIONS AND RECOMMENDATIONS

Geological conditions at the site are exceptionally favorable for construction of the proposed structures. The foundations, whether of overburden or of rock, are adequately strong to support the design loads. Bedrock foundation is available for all concrete structures. The only apparent major problem at this stage of the investigation is the uncertainty in precise location of embankment materials.

CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE IN FEET

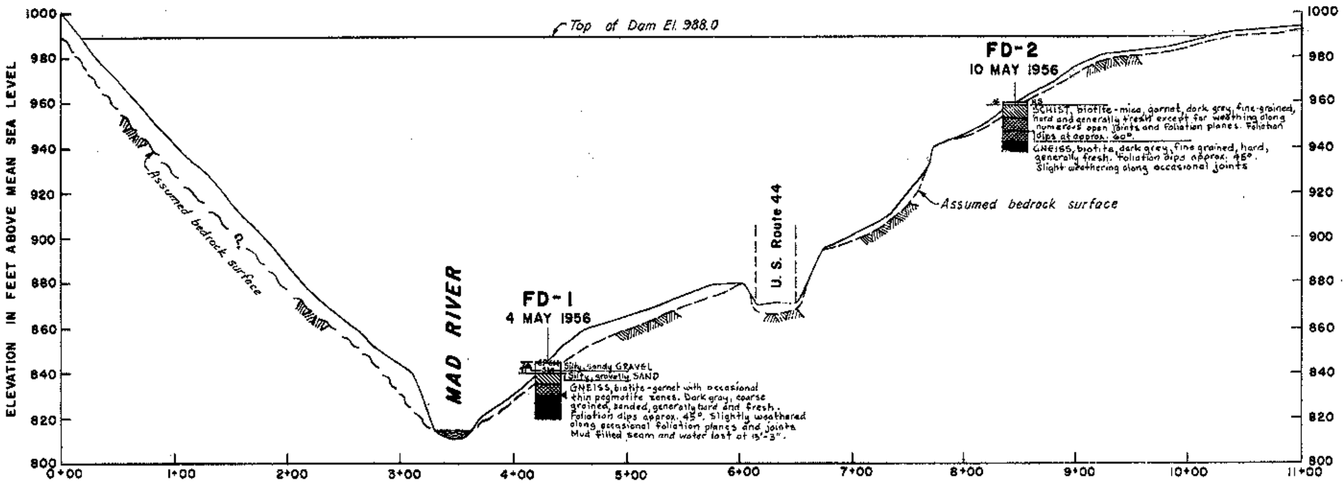
200 0 200 400

NOTES

Elevations refer to M.S.L. Datum.
Contour interval equals ten feet.

CORPS OF ENGINEERS, U. S. ARMY OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION BOSTON, MASS.		
DR. BY HEB / TR. BY LB / CK. BY HEB/R.C.G.	CONNECTICUT RIVER FLOOD CONTROL **MAD RIVER DAM** **PLAN OF EXPLORATIONS**	
PROJECT ENGINEER		
SUBMITTED BY: CHIEF, PLANN. & RPTS BRANCH	MAD RIVER	CONNECTICUT
APPROVED: CHIEF ENGINEERING DIV.	APPROVED: LT. COL., C.E., ASS'T. TO DIVISION ENGINEER	DATE JUNE 1956
TO ACCOMPANY REPORT DATED 14 JUNE 1956	SCALE: 1"=200' DRAWING NUMBER CT-2-1465 SHEET 1 OF 2	

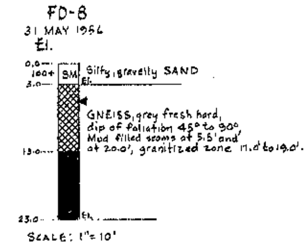
PLATE NO. A-1



GEOLOGIC-LOG SECTION A-A ℄ DAM

(LOOKING UPSTREAM)

SCALE HOR. 1" = 60' VERT. 1" = 30'



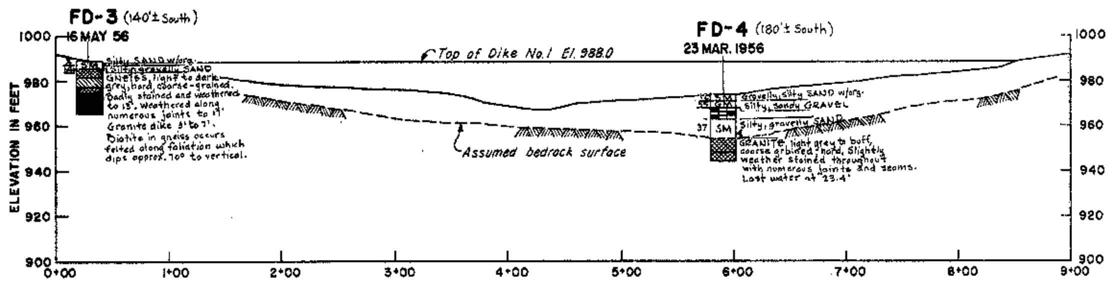
LEGEND FOR GRAPHIC LOGS

- **FD-1** Type and number of exploration
- 4 MAY 1956 Date exploration completed
- EL. 845.5 Elevation of ground surface, during time of exploration
- Subsurface water level in boring at time of exploration
- SM Group letter symbol according to Unified Soil Classification System
- NR No Recovery or unsatisfactory soil samples recovered
- NS Not Sampled (Core-drilled, blasted, and/or wash-bored.
- 70 Blows per foot of penetration considered most representative for each sample drive using a 300 pound hammer with free fall of about 18 inches on a 3" O.D. size sample spoon equipped with a bevelled and sharpened drive shoe.
- * Blow count not recorded or not considered representative
- Cobble or boulder (Core-drilled)
- Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped.)
- El. 839.5 Elevation of bedrock surface
- Rock core recovery 0-25%
- Rock core recovery 25-50%
- Rock core recovery 50-75%
- Rock core recovery 75-90%
- Rock core recovery 90-100%
- El. 820.5 Elevation at bottom of exploration

NOTES

Elevations refer to Mean Sea Level Datum.

For location of explorations and geologic sections, see plan of explorations.



GEOLOGIC-LOG SECTION B-B ℄ DIKE

(LOOKING SOUTH)

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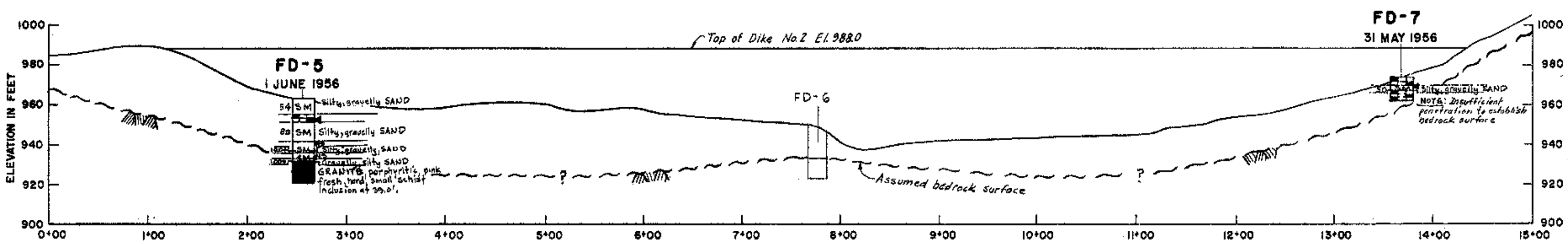

GEOLOGIC-LOG SECTION C-C ℄ DIKE

(LOOKING UPSTREAM)

SCALE HOR. 1" = 60' VERT. 1" = 30'

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY B.G. TR. BY B.G. CK. BY	CONNECTICUT RIVER FLOOD CONTROL
PROJECT ENGINEER	**MAD RIVER DAM**
SUBMITTED BY: CHIEF, PLANN. & RPTS BRANCH	**GEOLOGY**
APPROVED: CHIEF, ENGINEERING DIV.	MAD RIVER CONNECTICUT
	APPROVED: LT. COL., C.E., ASST. TO DIVISION ENGINEER — DATE JUNE 1956
	SCALE: AS SHOWN
TO ACCOMPANY REPORT DATED 14 JUNE 1956	DRAWING NUMBER CT-2-1466 SHEET 2 OF 2

APPENDIX B

FLOOD LOSSES AND BENEFITS

APPENDIX B

FLOOD LOSSES AND BENEFITS

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APPENDIX B

FLOOD LOSSES AND BENEFITS

B1. DAMAGE SURVEYS

Damage-survey parties were sent to the flood area during, and immediately after, the flood of August 1955. In view of the great increase in losses over previous floods, the information gathered was referenced to 1955 flood stages. Correlation with data obtained after 1938 and 1948 high waters was accomplished by an office review. Essentially, the survey was a door-to-door inspection of the hundreds of industrial, commercial, residential, and other properties affected by the flood. Information obtained included the extent of the areas flooded, descriptions of properties, the nature and amount of damages, depths of flooding, high-water references, and relationships to prior flood stages. Estimated evaluations of damage were generally furnished by property owners. Where these estimates appeared unrealistic, they were modified by the investigators. In those cases where owners were unable to furnish loss estimates, the investigators made their own evaluations. Sampling methods were employed where several residences of similar characteristics and like depth of flooding were encountered. Valuable information was also obtained from local and state officials and from utility companies which experienced damage at several points in this and other river basins. (Such central sources of information were extensively used to save time and to keep survey costs at a minimum.)

Sufficient data was obtained to derive losses for (1) the 1955 stage; (2) a stage 3 feet in excess of 1955; (3) intermediate stages denoting sharp changes in stage-damage relationships; and (4) the stage where damage begins (zero damage) referenced to the 1955 flood level.

B2. LOSS CLASSIFICATION

Flood-loss information was recorded by type of loss and by location. Loss types used were industrial, urban (commercial, residential, public), rural, highway, railroad, and utility. The type of loss was recorded by location within Winchester-Winsted and by reaches of the Mad and Still Rivers to provide a basis for later use in annual loss and benefit analyses. Damage reaches are described in Table B-I and shown on Plate B-I.

TABLE B-I

DESCRIPTION OF DAMAGE REACHES

MAD AND STILL RIVERS

River	Reach	Description of Reach
Mad River	C-15.1e(1)	Mad River Dam site to mouth of Highland Lake Outlet
	C-15.1e(2)	Mouth of Highland Lake outlet to Rowley Street Bridge (head of Still River backwater)
Still River	C-15.1f(1)	Tiffany and Pickett Lumber Company to Gilbert Clock Company Dam (including backwater on Mad River)
	C-15.1(2)	Gilbert Clock Company Dam to confluence with Sandy Brook

Losses were classified as direct or associated. Direct losses comprise (1) physical losses such as damage to structures, machinery, and inventory and cost of clean-up and repairs; and (2) non-physical losses such as unrecovered loss of business, wages, or production; increased cost of operation; cost of temporary facilities; and increased cost of shipment of goods to persons and properties in the inundated areas. Associated losses comprise increased cost of travel and shipment, loss of utilities and transportation, and unrecovered loss of production and wages in areas adjacent to the inundated areas.

The direct loss resulting from physical damage and a large part of the related non-physical loss are determined by direct inspection of property and evaluation of losses by the property owner and field investigators from this office or both. The non-physical portion of the direct loss is often difficult to estimate on the basis of information available at a given property. Where this condition exists, the relationship between physical and non-physical losses is based on the relationship found for similar properties in the area.

Associated losses are determined by field analysis and evaluation after consultation with the affected property owner; inconclusive results are supplemented where necessary by studying the relationship of associated losses to total losses in other New England river basins. In the Winsted area, associated losses accounted for 17.8 percent of the total.

Total losses for the August 1955 flood are summarized in Table B-II.

TABLE B-II - 1955 FLOOD LOSSES BELOW MAD RIVER

DAM, WINCHESTER-WINSTED AREA
(Loss in $1,000)

River	Reach	Urban	Rural	Industrial	Utility	Highway	Railroad	Total
Mad	15.1e(1)	710	0	1,440	380	760	0	3,290
	15.1e(2)	6,440	0	1,170	760	1,180	140	9,690
Still	15.1f(1)	1,320	0	2,620	300	860	90	5,190
	15.1f(2)	180	60	30	0	230	0	500
Total		8,650	60	5,260	1,440	3,030	230	18,670

B3. ANNUAL LOSSES

Estimated flood losses have been converted to annual losses to provide a basis for comparing annual benefits to annual costs. Annual-loss figures presented herein have been derived in accordance with standard Corps of Engineers practice utilizing stage-damage, stage-discharge, and discharge-frequency relationships. Typical curves used in annual-loss computations are shown on Plate B-1.

Stage-damage data for individual properties was summarized by reaches which have relatively uniform hydraulic characteristics throughout. The stage-damage curve was combined with stage-discharge data to develop a discharge-damage curve. A discharge-frequency relationship was then used to obtain a curve for the damage-frequency relationship. This curve was plotted with damage as the ordinate and percent chance of occurrence (reciprocal of frequency) as the abscissa. The area under the damage-frequency curve is a measure of the annual loss.

Annual losses for the four reaches of the Mad and Still Rivers below the Mad River dam are summarized below:

Reach	Annual Losses
C-15.1e(1)	$ 78,000
C-15.1e(2)	109,000
C-15.1f(1)	120,000
C-15.1f(2)	20,000
Total	$ 327,000

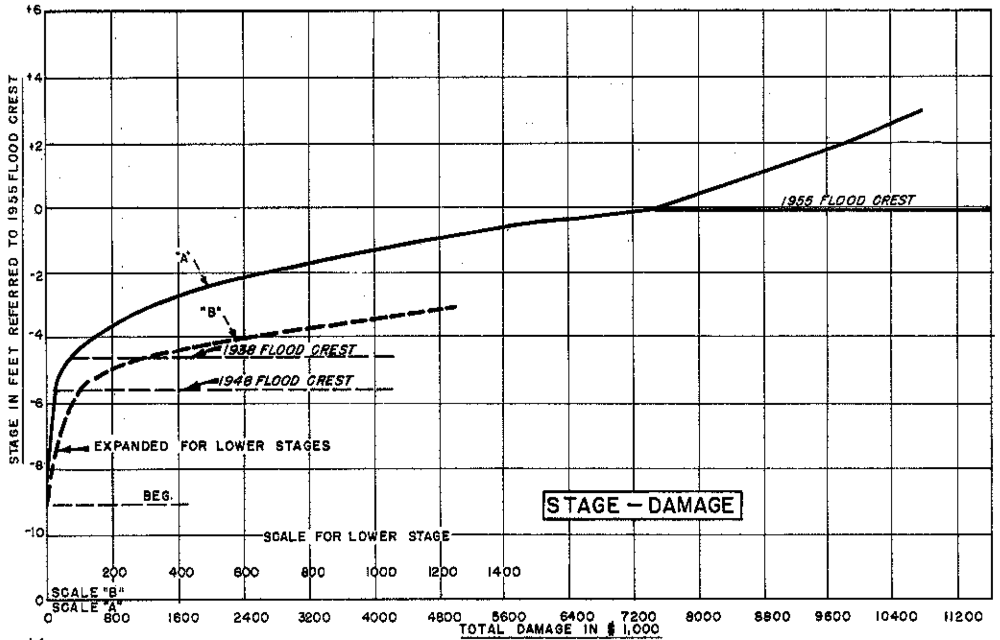
B4. EFFECT OF MAD RIVER RESERVOIR

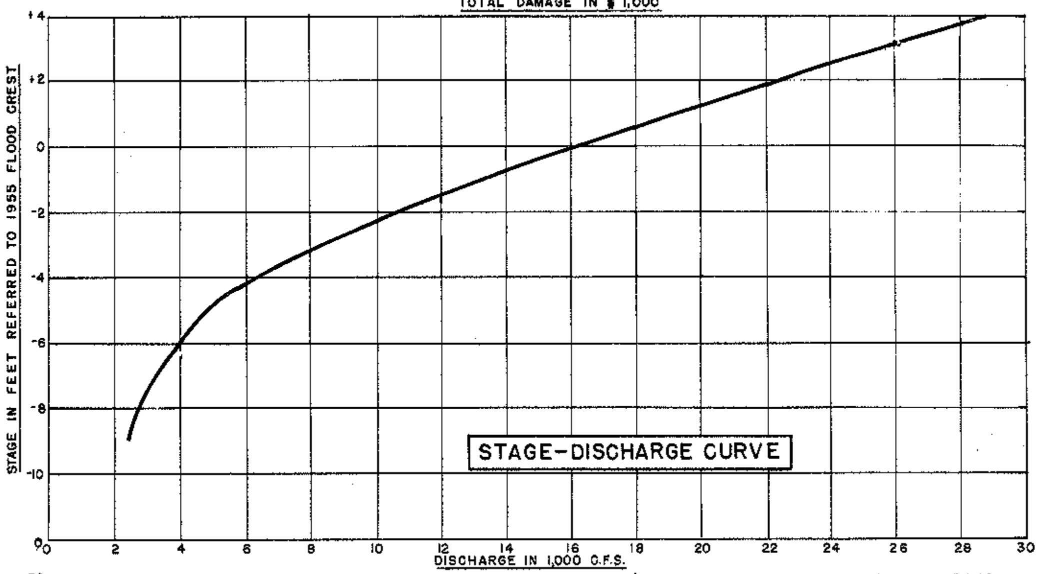
The Mad River Reservoir would reduce 1955 flows of 15,100 c.f.s. on the Mad River and 18,200 c.f.s. on the Still River to 6,500 c.f.s. and 9,800 c.f.s., respectively. It is estimated that flow reductions of this magnitude would produce savings of $8,150,000 along the Mad River and $3,220,000 along the Still River.

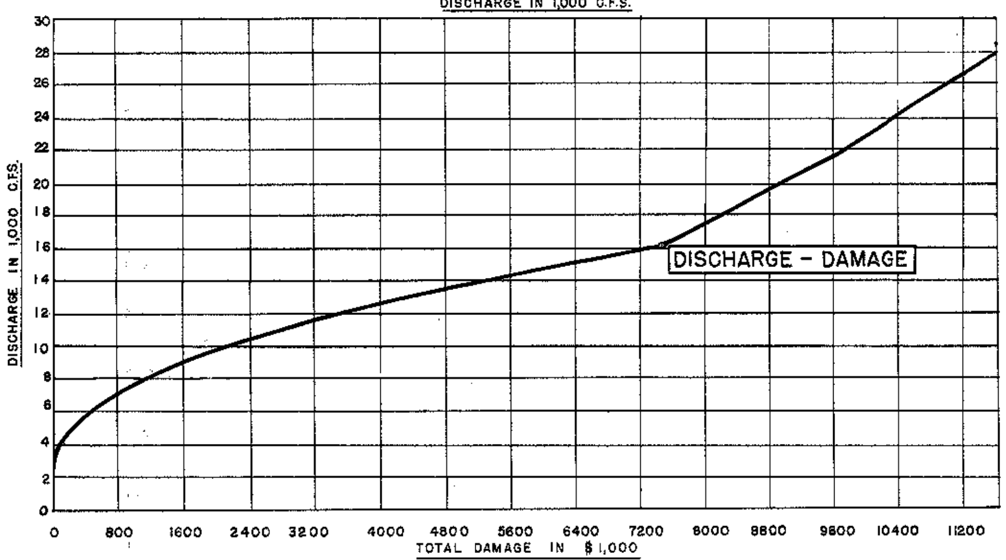
B5. ANNUAL BENEFITS

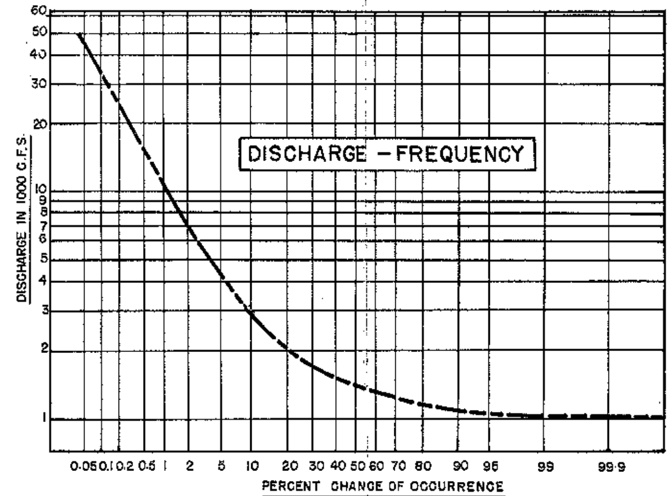
Annual benefits were derived for the reaches downstream of the project by determining the difference between the annual losses under present conditions and those remaining after construction of the Mad River project. Concurrent with determination of annual losses under present conditions, losses were determined for reductions in peak discharge of 10, 20, 40, and 60 percent. The reduction in losses resulting from the reduction in discharge represents the benefits resulting from reduction of flows. In this manner a relationship is established between annual benefits and reduction in flows.

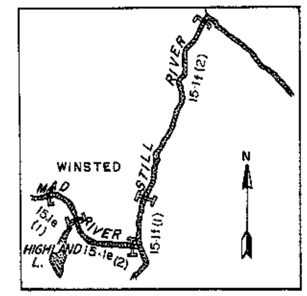
Reductions in flow to be realized by the project are determined by hydrologic analysis and applied to the relationship to obtain annual benefits from the reduction in flood damages. Annual benefits for the Mad River project are estimated at $263,000 with $162,000 being realized in the Mad River and $101,000 being realized in the Still River. No benefits have been credited to the project below the mouth of the Still River.



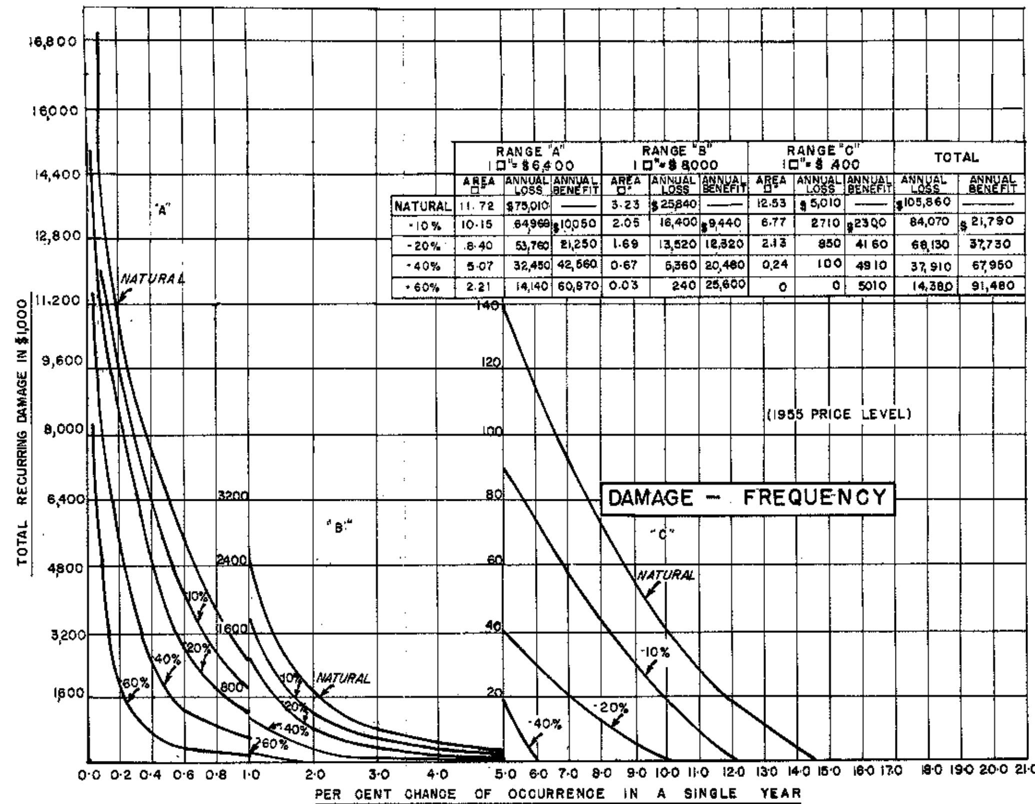




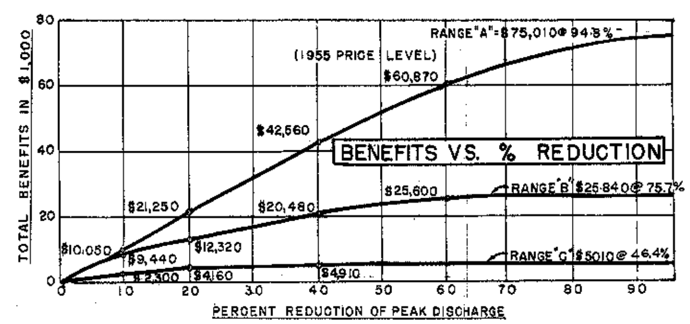




REACH MAP
No Scale



	RANGE "A" 1□"= $6,400			RANGE "B" 1□"= $ 8000			RANGE "C" 1□"= $ 400			TOTAL	
	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	11.72	$75,010	——	3.23	$25,840	——	12.53	$5,010	——	$105,860	——
-10%	10.15	64,969	$10,050	2.05	16,400	$9,440	6.77	2710	$2300	84,070	$21,790
-20%	8.40	53,760	21,250	1.69	13,520	12,320	2.13	850	4160	68,130	37,730
-40%	5.07	32,450	42,560	0.67	5,360	20,480	0.24	100	4910	37,910	67,950
-60%	2.21	14,140	60,870	0.03	240	25,600	0	0	5010	14,380	91,480



CONNECTICUT RIVER BASIN
FARMINGTON RIVER
(MAD RIVER)

DATA FOR ECONOMIC ANALYSIS
DAMAGE ZONE 15.1e (2)

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

APPENDIX C

LETTERS OF CONCURRENCE AND COMMENT

APPENDIX C

LETTERS OF CONCURRENCE AND COMMENT

Exhibit No.	Source
1	Winchester Flood and Erosion Control Board
2	The Industrial Development Commission of Winsted
3	Fish and Wildlife Service, Department of the Interior
4	Federal Power Commission
5	State of Connecticut Flood Control and Water Policy Commission

TELEPHONE: FRontier 9-6994

Town of Winchester - City of Winsted

Selectmen's Office

FLOOD CONTROL BOARD
Emile H. Ryan, Chairman
Joseph W. Rosgen, Secretary
P. Francis Hicks
Robert Morgan
W. Arthur Hayes

Winsted, Conn., June 7, 1956

File No. NEDVG

Brig. General Robert J. Fleming, Jr.
Division Engineer
Corps of Engineers, U. S. Army
New England Division
150 Causeway St.
Boston 14, Mass.

Dear Sir:

The Flood and Erosion Control Board of the Town of Winchester wishes to go on record supporting the construction of the proposed dry dam on the Mad River. It is our feeling that this dam would capture and hold waters draining from the largest watershed in the Town of Winchester.

Its construction would dislocate a very small number of relatively inexpensive homes. We have interviewed almost all of the home owners now living in the proposed dam area, and the general feeling of these people seems to be that the future safety of Winsted is far more important than the preservation of their present homes.

The construction of this dry dam will give us more assurance of retaining existing industries and will help considerably in encouraging the expansion of existing industries and the locating of new industries in our community. The economy of the Town of Winchester is completely dependent upon manufacturing.

In our opinion, based upon the engineering data made available to us after the disastrous August flood of 1955 and engineering data supplied to us by your office since that time, the existence of the dry dam prior to the August flood would have prevented seventy-five per cent of the damage sustained.

Dry dams constructed in other parts of New England, designed by your office, have certainly proven themselves to be invaluable. The construction of this dry dam in the Mad River area will also undoubtedly have its effect upon the lower Farmington Valley in the event of another flood.

EXHIBIT 1

Your knowledge of flood control methods and the study made by your office outlining our needs for flood control is, in itself, sufficient reason for supporting and seeking a dry dam on Mad River.

Very truly yours,

Emile H. Ryan

Selectman Emile H. Ryan, Chairman
Winchester Flood and Erosion Control Board

EHR/c

The following telegram was sent to Senator William Purtell and Congressman James Patterson, members of the Connecticut congressional delegation:

THE INDUSTRIAL DEVELOPMENT COMMISSION OF WINSTED VOTED LAST NIGHT TO FULLY ENDORSE THE ERECTION OF THE PROPOSED DRY DAM NORTH WEST OF WINSTED STOP AFFIRMATIVE ACTION BY YOU IN WASHINGTON WOULD BE MOST APPRECIATED IN CUTTING RED TAPE TO EXPEDITE THIS PROJECT

L F LEIGHTON SECRETARY

EXHIBIT 2

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

REGION 5

NEW ENGLAND STATES
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
WEST VIRGINIA

May 14, 1956

800.5 (Naugatuck Conn.)

Division Engineer
New England Division
U. S. Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to your letter of May 4, 1956 in which you requested comments from this office in relation to three potential reservoirs in Connecticut. The three reservoirs under consideration are East Branch Nangatuck, Hall Meadow Brook and Mad River.

The information concerning these reservoirs in the attachment is of a preliminary nature and is based on a cursory field examination of the proposed reservoir sites. The information is not regarded as adequate to fulfill our obligations under the Coordination Act (60 Stat. 1080).

This office welcomes the opportunity to comment on these projects during preliminary stages of planning. Detailed reports will be prepared when required by your office.

Very truly yours,

E. W. Bailey
Acting Regional Director

Attachment

EXHIBIT 3

Mad River

This project would be situated on the Mad River just upstream from Winsted, Connecticut. Wildlife values are nominal on this semi-developed area. As in the case of the East Branch project, considerable of the 180 acres are devoted to homesites. Wildlife losses would be minor and would compare to the minor losses expected at East Branch. Free access for hunting should also be provided at this project in the post-development period.

The Mad River also is a trout stream that is stocked annually by the State of Connecticut. It is an attractive stream, but is badly scoured as a result of flooding. Although some damages would accrue as a result of flooding in the post-development period, these damages could be considerably reduced if woody cover were left standing along the stream in the reservoir area.

FEDERAL POWER COMMISSION
REGIONAL OFFICE
139 CENTRE STREET, NEW YORK 13, N. Y.

May 16, 1956

800.5 (N.E.D.)

The Division Engineer
New England Division
Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to your letter of May 4, 1956 inclosing data on three potential dam and reservoir projects currently being studied by your staff in connection with the New England flood control program and requesting our comments thereon.

Two of the projects, East Branch, Naugatuck River and Hall Meadows Brook, are located in the Housatonic River basin and one, Mad River Reservoir, on the Farmington River, a tributary of the Connecticut River basin.

It is understood that these reservoirs will be operated for flood control only and no permanent pool for recreation or other purposes is planned at this time. Pertinent data on the projects as shown in the referenced letter are summarized in the following:

Project	East Branch Naugatuck River	Hall Meadows Brook	Mad River Reservoir
River Basin	Housatonic	Housatonic	Connecticut
Drainage Area, sq.mi.	9.25	12.2	18.15
Capacity, Ac.Ft.	5,150	7,200	9,630
Reservoir Area, Acres	180	350	180
Top Elevation Dam, m.s.l.	886	905	988
Elevation SpillwayCrest,msl	871	890	973
Maximum Height dam, feet	95	55	168

In view of the small drainage area controlled by the projects and the need to preempt available storage capacity for flood control only, this office concludes that the development of hydroelectric power or conservation storage at these projects would not be economically feasible.

Very truly yours,

DJWait

D. J. Wait
Regional Engineer

EXHIBIT 4

The following is an excerpt from a letter dated 15 May 1956 from John J. Curry, Chief Engineer, State of Connecticut Flood Control and Water Policy Commission, to Mr. H. J. Krepper, Chief, Engineering Division, New England Division, Corps of Engineers, U. S. Army:

Reference is made to your letters of 19 April and 2 May, requesting comments on a proposed system of flood control dams in the Naugatuck River basin and one in the Farmington River above Winsted. This office is vitally interested in a proposal of this type which calls for the construction of storage reservoirs on small drainage basins. In our studies of these matters in 1948 and 1949, we tabulated all the drainage basins in Connecticut which were larger than 25 square miles and which did not have a railroad running along the valley bottom. Within the State there are only 25 such basins. We may assume that if such a basin does not control more than 10% of the area above a population center of 5,000, it probably has little value for flood control. Such a criteria eliminates 15 of these 25 areas as possible locations for flood control structures. One of these is too large for a practical structure; four of them are already controlled and another will be. Of the remaining four, two are relatively unimportant, and the other two happen to be the Naugatuck River above Torrington and Mad River above Waterbury. We, therefore, concluded at that time and we are more convinced at present that if Connecticut is to obtain further flood control by storage reservoirs after the Thomaston Dam is completed, such control must be constructed in the small drainage basins you are considering.

We have not at the time of your request for our opinion received a copy of the general plan of small reservoirs for the Farmington River. We do have some knowledge of your proposal for a dam on the Mad River above Winsted. We believe that the construction of such a dam would have great value in eliminating a constant threat of flood to the central business section of Winsted. There is no doubt that this area is unusually prone to flood damage because of the steepness of the topography above the town and the restriction of the carrying capacity of the stream by the economic development along Main Street. The provision of local protection in Winsted would necessitate a difficult design problem. The earlier attempt to provide as much protection as possible proved to be an unsatisfactory approach. Under the present plans for the improvement of the State Highway and the reconstruction of the Winsted business area it becomes even more difficult to provide protection by local works against a more reasonably sized flood within the confines imposed by the topography and economical development.

EXHIBIT 5

The construction of the proposed dam would so reduce the flood flow through Winsted that the requirement of local protection would be either eliminated or reduced to the extent that it could practicably be provided. It could very well be that this is the only possible solution for the overall problem in Winsted. It appears that the dislocation required is small in comparison to the benefits to be achieved.

APPENDIX D

HYDROLOGY

APPENDIX D

HYDROLOGY

TABLE OF CONTENTS

APPENDIX D (Cont.)

APPENDIX D

HYDROLOGY

D1. CLIMATOLOGY

D1.1 Temperature. - The average annual temperature in the Farmington River watershed varies from 45°F. in the mountains to about 50°F. in the valley. Freezing temperatures may be expected from the middle of November until the end of March. Table D-I summarizes mean, maximum, and minimum monthly temperatures at Norfolk and Hartford, approximately the upper and lower ends of the valley.

TABLE D-I - MEAN MONTHLY TEMPERATURES
(Degrees Fahrenheit)

	Norfolk			Hartford		
Period of Record	1948-1955			1921-1955		
Elevation m.s.l.	1,380			169		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	23.3	29.3	14.0	27.3	37.0	17.4
February	23.8	28.3	17.8	28.7	36.2	16.5
March	30.2	32.3	24.3	37.4	46.2	31.0
April	44.0	46.1	40.3	48.3	53.6	42.8
May	54.2	58.6	50.9	59.6	64.2	51.0
June	62.9	66.6	60.8	68.8	72.3	63.0
July	68.5	72.2	65.7	73.9	77.0	69.4
August	66.2	69.4	63.1	71.3	75.2	66.6
September	57.9	59.8	55.1	63.7	68.8	59.5
October	49.0	52.8	42.2	53.1	58.2	46.7
November	37.1	42.2	32.1	41.3	47.1	37.4
December	26.1	31.4	18.7	29.9	38.6	20.9
Annual	45.2	47.2	44.0	50.2	59.4	40.9

D1.2 Precipitation. - Mean annual precipitation over the Farmington River watershed is approximately 50 inches uniformly distributed throughout the year. At the Peoples Ranger Station, 3 miles east of Winsted, the maximum and minimum annual precipitation for 8 years of record through 1955 were 65.76 inches in 1955 and 38.61 inches in 1949 (Table D-II). At Norfolk, in the headwaters of the Naugatuck River adjacent to the headwaters of the Mad River, the maximum and minimum annual precipitation for 11 years of record through 1955 were 76.0 inches in 1955 and 39.68 inches in 1946.

TABLE D-II - MONTHLY PRECIPITATION RECORD
(Inches)

	Peoples Ranger Station			Norfolk		
Period of Record	1947-1955			1945-1955		
Elevation m.s.l.	435			1,380		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	4.00	6.69	0.78	4.47	8.32	0.93
February	3.38	5.01	2.47	3.96	5.72	2.44
March	5.09	10.34	3.06	4.75	10.37	1.82
April	4.41	6.68	2.67	4.90	7.19	2.88
May	4.11	5.95	1.61	4.90	8.14	1.72
June	3.93	6.50	1.17	4.39	8.85	1.11
July	2.70	3.58	1.24	3.93	9.33	1.67
August	5.37	21.00	1.20	5.34	23.67	0.65
September	2.81	6.92	0.63	4.34	9.25	0.92
October	4.21	15.37	1.21	4.21	17.49	1.86
November	4.98	8.14	1.48	5.45	10.03	1.51
December	4.42	7.53	0.99	5.00	9.40	1.20
Annual	49.87	65.76	38.61	55.66	76.00	39.68

D1.3 Snowfall. - Average annual snowfall varies from about 80 inches in the headwaters to approximately 40 inches in the lower portion of the watershed. During the winter of 1955-1956, water content of the abnormally high snow cover averaged about 5 inches.

D2. HISTORY OF FLOODS

D2.1 Historic Floods. - Records of major floods in the Farmington River watershed date back to January 1770 and include the floods of May 1801, November 1853, May 1854, October 1869, December 1878, and March 1896. There is no reliable information concerning the magnitude of these floods; however, those of October 1869 and December 1878 were the most severe and caused considerable damage. Major floods since 1900 occurred in November 1927, March 1936, September 1938, December 1948, and August and October 1955.

D2.2 Streamflow Data. - The U.S. Geological Survey has published records of river stages and streamflows at seven locations in the Farmington River watershed for various periods since 1913. In addition, flow data from Barkhamsted, East Branch, Nepaug, and Whigville Reservoirs are published by the U.S.Geological Survey from information furnished by the Water Bureau of the Metropolitan District Commission, Hartford, and by the New Britain Board of Water Commissioners. The records are generally good to excellent except during periods of ice when they are fair. Following major floods, peak-discharge data has been computed by the U.S.G.S. for many locations on the smaller tributaries (Table D-III).

TABLE D-III - STREAMFLOW RECORDS

FARMINGTON RIVER WATERSHED

Location of Gaging Station	Drainage Area (sq.mi.)	Period of Record	Discharge Mean(1) (c.f.s.)	Discharge Maximum(2) (c.f.s.)	Discharge Minimum (c.f.s.)
W. Branch, Farmington River (near New Boston, Mass.)	92	1913-	182	34,300	6
Still River (Robertsville, Conn)	84.4	1948-	183	44,000	6
W. Branch, Farmington River (Riverton, Conn)	216	1929-	392	101,000	23
Burlington Brook (near Burlington, Conn)	4.12	1931-	8	1,720	0.1
Pequabuck River (Forestville, Conn)	45.2	1941-	82	11,700	6
Salmon Brook (near Granby, Conn)	60.6	1946-	120	40,000	10
Farmington River (Rainbow, Conn)	584	1928-	1,041	69,200	5

(1) Includes 1952 water year
(2) Instantaneous discharge, August 1955

D2.3 Major Floods. - The Farmington River watershed has experienced six major floods in recent years. Table D-IV gives the peak discharges of these floods at the U.S. Geological Survey gaging stations at New Boston, Massachusetts, and Rainbow, Connecticut.

TABLE D-IV - MAJOR FLOODS

FARMINGTON RIVER WATERSHED

		New Boston	Rainbow
Drainage Area (sq.mi.)		92	584
Flood		Peak Discharge (c.f.s.)	Peak Discharge (c.f.s.)
November	1927	6,610	-
March	1936	9,080	26,900
September	1938	18,500	26,900
December	1948	11,700	26,500
August	1955	34,300	69,200
October	1955	20,000	34,700

The 1927 flood resulted after an average rainfall of 6 inches on 3-4 November on ground already saturated from excessive rains during the previous month. The flood of March 1936 was caused by four distinct storm centers that passed over the northeastern states between 9 and 22 March; the runoff from these storms was augmented by considerable snow-melt. The September 1938 flood resulted when a hurricane passed over New England on 21 September and deposited over 10 inches of precipitation on ground soaked by rainfall which occurred earlier in the month. The flood of December 1948 resulted from 9 - 10 inches of rain on frozen ground and was augmented by some snowmelt. The flood of August 1955 was caused by rainfall associated with hurricane "Diane" when the basin was already saturated by rain from hurricane "Connie." The rainfall, which varied from 8 - 18 inches, caused the flood of record in the entire Farmington River watershed. The flood of October 1955 resulted from a storm that moved up the Atlantic Coast from Florida and dumped 9 inches of rainfall over the watershed.

D2.4 Flood Profiles. - High-water profiles were determined from field data following the December 1948 floods and August 1955 flood. High-water profiles for the Mad and Still Rivers are shown on Plate 2 of the main report.

D2.5 Flood Frequencies. - The frequency or percent chance of occurrence of peak discharges was determined from records of all gaging stations in the watershed. The frequency analyses were made in accordance with the procedures described in Civil Works Engineer Bulletins 51-1 and 51-14. Application to New England rivers is summarized in F.C.S. Memorandum No. 52- General-3, "Flood Frequency Studies in New England," distributed with Civil Works Bulletin 53-5 (2 April 1953). The method assumes that the logarithmic values of annual peak flows are normally distributed, thereby permitting the application of standard statistical analysis. This enables the discharge frequency curve to be defined by its mean value and standard deviation. Based on a review of New England river basins which included the 1955 floods, a skew factor of 1.0 was adopted for the Farmington River instead of the skew factor of 0.3 used previously. The basic frequency data for gaging stations was used to derive frequency curves applicable to the damage zones for economic studies. Frequency curves at the damage zones in the vicinity of Winsted, Connecticut are shown on Plate D-1.

D3. ANALYSIS OF FLOODS

D3.1 Scope and Purpose. - For this report, the analysis of floods was limited to the Still and Mad Rivers. The U.S. Geological Survey established a gaging station on the Still River at Robertsville in 1948, and data from this gaging station together with isolated peak-discharge data obtained during various floods were utilized in analyzing the floods on the Mad and Still Rivers.

D3.2 Hydrologic Description of Basin. - The 18.2 square miles of watershed above the Mad River Reservoir has a length of approximately 6 miles and a maximum width of about 4 miles. The topography is generally hilly with elevations varying from about 850 at the dam site to a maximum of 1,627 in the headwaters. Several hills are approximately elevation 1,500. The relatively steep slopes of the hills are stony and conducive to rapid surface runoff. Ponds and reservoirs in the area are few and small and have little influence on flood flows. Although the valleys contain meadowlands and swamp areas, the flood history of the area indicates that these too have little effect on the runoff from major storms.

The slope of the river generally decreases as it approaches the site of the reservoir and is confined to a narrow valley with no valley storage. The river drops about 250 feet in the 3 miles above the dam site, an average of more than 80 feet per mile. The slope continues steep below the dam and through the city of Winsted. These steep channel slopes and the convergence of several tributaries just upstream of Winsted produce a funnelling action leading to the high peak flows that have been experienced at Winsted.

Discharge from the 7.3 square miles of drainage area partially controlled by Crystal and Highland Lakes enters the Mad River in the upper part of Winsted. These reservoirs are normally full; although the surcharge storage appreciably modifies runoff during moderate storms, the lakes have only minor influence during major storms. Their principal beneficial effect during large floods is to delay the peak discharge enough so that it does not coincide with the peak flows on the Mad River. Local observers report that the maximum discharge from Highland Lake occurs about 5 hours after the peak on the Mad River.

The Still River, which receives the discharge from the Mad River, is quite flat and has considerable valley storage, especially just upstream of the mouth of the Mad River. (It is suspected that part of this storage is filled by the rapid runoff from the Mad River that cannot be absorbed by the limited channel capacity of the Still River.) The hydraulic control for this reach of the Still River was the narrow rock gorge and dam at the Gilbert Clock Company located in lower Winsted. The dam was destroyed by the 1955 flood, and the rock gorge has been recently enlarged by operations of the Disaster Relief Organization.

Below the Gilbert Clock Company the river is again flat with some significant valley storage to modify the flood crests. Sandy Brook, with a drainage area of 33.8 square miles, enters the Still River at Robertsville. The characteristics of Sandy Brook are comparable to those of Mad

River with more slope and rugged topography in the lower part of the basin than in the upper.

A. U.S.G.S. gaging station is located om the Still River less than 0.5 mile below the mouth of Sandy Brook. It is believed that there is reasonably close synchronization of flows from the Mad River and Sandy Brook although there may be some tendency for the flows from Mad River to be delayed by valley storage in the Still River. The Still River discharges into the Farmington River at Riverton, Connecticut. The total drainage area of the Still River is 86.6 square miles.

D3.3 Analysis. - For purposes of hydraulic analysis, the watershed was divided into four routing reaches with limits at the Mad River Dam site, mouth of Mad River, Still River at Gilbert Clock Company Dam, and the confluence of the Still River and Sandy Brook. Synthetic hydrographs were developed for each contributing area by a study of rainfall distribution, unit hydrographs, and the runoff hydrographs from comparable gaged areas. The component hydrographs of the contributing areas were routed downstream to determine their contributions to the peaks at the damage zones. Plate D-2 shows the component hydrographs of the 1955 flood at selected locations on the Still River. The peak-discharge profile for the August 1955 flood is shown in Plate D-3. Table D-V shows tributary contributions to flood peaks in August 1955 and September 1938. Floods in the Still River watershed develop in the headwaters of the Mad River and Sandy Brook.

TABLE D-V - TRIBUTARY CONTRIBUTION TO FLOODS OF RECORD AND STANDARD PROJECT FLOOD

(1) Estimated
(2) USGS Peak = 44,000 c.f.s.

Tributary	Drainage Area (sq.mi.)	Drainage Area (%)	August 1955 Discharge (c.f.s.)	August 1955 Discharge (%)	September 1938(1) Discharge (c.f.s.)	September 1938(1) Discharge (%)	Standard Project Flood Discharge (c.f.s.)	Standard Project Flood Discharge (%)
Mad River Dam Site	18.2	100.0	10,100	100.0	2,240	100.0	14,700	100.0
Mad River at Mouth								
Mad River Dam Site	18.2	54.6	9,600	63.5	2,240	67.9	14,600	62.7
Highland Lake	7.3	22.0	1,400	9.3	100	3.0	2,500	10.7
Local	7.8	23.4	4,100	27.2	960	29.1	6,200	26.6
Total	33.3	100.0	15,100	100.0	3,300	100.0	23,300	100.0
Still River at Gilbert Clock Company								
Mad River Dam Site	18.2	43.5	9,400	51.6	2,240	60.5	14,000	52.0
Highland Lake	7.3	17.5	1,400	7.7	100	2.7	2,400	8.9
Local	7.8	18.6	4,000	22.0	960	26.0	6,000	22.3
Still River	8.5	20.4	3,400	18.7	400	10.8	4,500	16.8
Total	41.8	100.0	18,200	100.0	3,700	100.0	26,900	100.0
Still River at U.S.G.S. Gage at Robertsville								
Mad River Dam Site	18.2	21.6	8,700	24.4	2,100	21.0	11,900	25.2
Highland Lake	7.3	8.6	700	2.0	100	1.0	1,400	3.0
Local	7.8	9.2	3,700	10.4	900	9.0	5,100	10.8
Still River	17.3	20.5	6,300	17.7	900	9.0	7,800	16.5
Sandy Brook	33.8	40.1	16,200	45.5	6,000	60.0	21,000	44.5
Total	84.4	100.0	35,600(2)	100.0	10,000	100.0	47,200	100.0

D4. STANDARD PROJECT FLOOD

D4.1 Rainfall. - The standard project flood developed for the Still River watershed is based on standard-project-storm rainfall as described in Civil Engineers Bulletin No. 52-8. A tabulation of 3-hour rainfall and rainfall excess is shown in Table D-VI.

TABLE D-VI - STANDARD-PROJECT-STORM RAINFALL

Time (hours)	3-Hour Rainfall (inches)	Losses (inches)	Rainfall Excess (inches)
0	0	0	0
3	6.86	0.21	6.65
6	1.72	0.21	1.51
9	0.92	0.21	0.71
12	0.60	0.21	0.39
15	0.50	0.21	0.29
18	0.40	0.21	0.19
21	0.30	0.21	0.09
24	0.30	0.21	0.09
Total	11.60	1.68	9.92

D4.2 Unit Hydrographs. - The 1-hour unit hydrographs adopted for the standard project flood were determined from analysis of the August 1955 flood. At the Mad River Dam site, the peak discharge of the 1-hour unit hydrograph was equivalent to 118 c.f.s. per square mile with a time of concentration of 2 hours.

D4.3 Flood Discharges. - The peak discharge of the standard project flood at the proposed Mad River Reservoir is 14,700 c.f.s.; at Winsted it is 23,300 c.f.s., approximately 1.5 times the August 1955 flood. Table D-V summarizes tributary contributions to the peak of the standard project flood at selected locations on the Mad and Still Rivers.

D5. MAD RIVER RESERVOIR

The Mad River Dam and Reservoir is located in the town of Winchester, Connecticut, about 2.2 miles above its confluence with the Still River. The reservoir will control 18.2 square miles of drainage area or over 56 percent of the 33.3 square mile drainage area of the Mad River, and over 43 percent of the 41.8 square mile drainage area above the Gilbert Clock Company on the Still River. The capacity of the reservoir at spillway crest (elevation 973 feet m.s.l.) will be 9,630 acre-feet, equivalent to 10 inches of runoff from the drainage area. The hydrologic analyses used to determine the spillway and outlet requirements for the project are described in Sec. D6, below.

D6. SPILLWAY DESIGN FLOOD

D6.1 Probable Maximum Precipitation. - Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 33 (April 1956). Losses from infiltration, surface detention, and transpiration and from certain intangible factors were assumed at a rate of 0.05 inch per hour. The probable maximum precipitation and rainfall excess was arranged in a pattern to give the most critical runoff conditions.

TABLE D-VII - PROBABLE MAXIMUM PRECIPITATION

Time (hours)	Maximum Precipitation (inches)	Losses (inches)	Rainfall Excess (inches)
0	0	0	0
3	15.06	0.15	14.91
6	7.54	0.15	7.39
9	1.60	0.15	1.45
12	1.00	0.15	0.85
15	0.80	0.15	0.65
18	0.60	0.15	0.45
21	0.60	0.15	0.45
24	0.60	0.15	0.45
Total	27.80	1.20	26.60

D6.2 Unit Hydrograph. - The 1-hour unit hydrograph adopted for the spillway design flood was determined from analysis of the August 1955 flood and from unit hydrographs derived for small drainage areas with similar runoff characteristics. The peak discharge of the adopted unit hydrograph is 2,280 c.f.s., or 125 c.f.s. per square mile.

D6.3 Spillway Design Flood. - The spillway-design-flood inflow for Mad River Reservoir was developed from the probable maximum precipitation and the adopted unit hydrograph. The peak of the spillway design flood is 38,600 c.f.s., equivalent to 2,120 c.f.s. per square mile. Assuming the reservoir initially contained 6 inches of storage (elevation 953), the spillway-design-flood inflow was routed through the remaining flood-control storage and the surcharge storage; various spillway lengths were used. A spillway length of 250 feet was adopted as the most economical. Because of insignificant surcharge storage, the resulting maximum spillway discharge was practically equal to the maximum inflow and produced a maximum surcharge of 12.2 feet. The top of dam was established at 15 feet above spillway crest providing 2.8 feet of freeboard. Table D-VIII summarizes the maximum discharges and elevations for the selected spillway length.

TABLE VIII - MAD RIVER RESERVOIR

PERTINENT DATA

Drainage area	18.2 sq.mi.
Storage at spillway crest	9,630 acre-feet (10 inches of runoff)
Peak spillway-design-flood inflow	38,600 c.f.s.
Peak spillway-design-flood outflow	38,000 c.f.s.
Pool elevation at beginning of flood (6 inches storage)	953 feet m.s.l.
Spillway length	250 feet
Spillway elevation	973 feet m.s.l.
Surcharge	12.2 feet
Freeboard	2.8 feet
Top of dam	988 feet m.s.l.

D7. OUTLET SIZE

The outlet for Mad River Dam would be a 48-inch ungated concrete conduit. Flood flows exceeding the capacity of the conduit would be stored in the reservoir. Size of the conduit was based on the following criteria:

(1) The conduit would pass the normal flow of the river without utilizing excess reservoir storage;

(2) When the reservoir is full to spillway crest, the discharge through the conduit would equal the downstream channel capacity;

(3) The discharge capacity of the conduit would be sufficiently restricted to effectively use reservoir storage, yet would be large enough to empty the reservoir within a reasonable time.

D8. EFFECT OF RESERVOIR REGULATION

D8.1 Flood of August 1955. - The effectiveness of the proposed Mad River Reservoir on a recurring flood comparable to the flood of August 1955 is shown on Plate D-4. The peak flood discharge at the dam site would have been reduced from 10,100 c.f.s. to 500 c.f.s., a total reduction of 9,600 c.f.s. The floodwaters stored in the reservoir would have created a maximum pool stage of 967.3 feet m.s.l., equivalent to 9.1 inches of storage or 91 percent of the total.

D8.2 Standard Project Flood. - The proposed reservoir would contain the entire standard project flood except for the discharge which would pass through the ungated outlet. The discharge reduction in the vicinity of Winsted would be 13,800 c.f.s. -- that is, the natural peak of 23,300 would be reduced to 9,500 c.f.s.

D8.3 Summary. - The proposed Mad River Dam and Reservoir would reduce flood flows in the vicinity of Winsted. Table D-IX summarizes the discharge reductions which would have been afforded by the reservoir at the damage zones for the floods of August 1955 and September 1938 and for the standard project flood.

TABLE D-IX - EFFECT OF MAD RIVER RESERVOIR

AT DOWNSTREAM DAMAGE CENTERS

Damage Zone	August 1955			September 1938			Standard Project Flood		
	Natural (c.f.s.)	Mod. (c.f.s)	Red. (c.f.s.)	Natural (c.f.s.)	Mod. (c.f.s.)	Red. (c.f.s.)	Natural (c.f.s.)	Mod. (c.f.s.)	Red. (c.f.s.)
Dam site to Highland Lake outlet	14,200	4,600	9,600	3,200	1,500	1,700	21,000	6,800	14,200
Highland Lake outlet to Rowley St. Bridge	15,100	6,500	8,600	3,300	1,700	1,600	23,300	9,800	13,500
Rowley St. Bridge to Gilbert Clock Co.	18,200	9,800	8,400	3,700	2,100	1,600	26,900	14,200	12,700
Gilbert Clock Co. to Sandy Brook	20,200	11,700	8,500	4,000	2,400	1,600	29,000	16,300	12,700

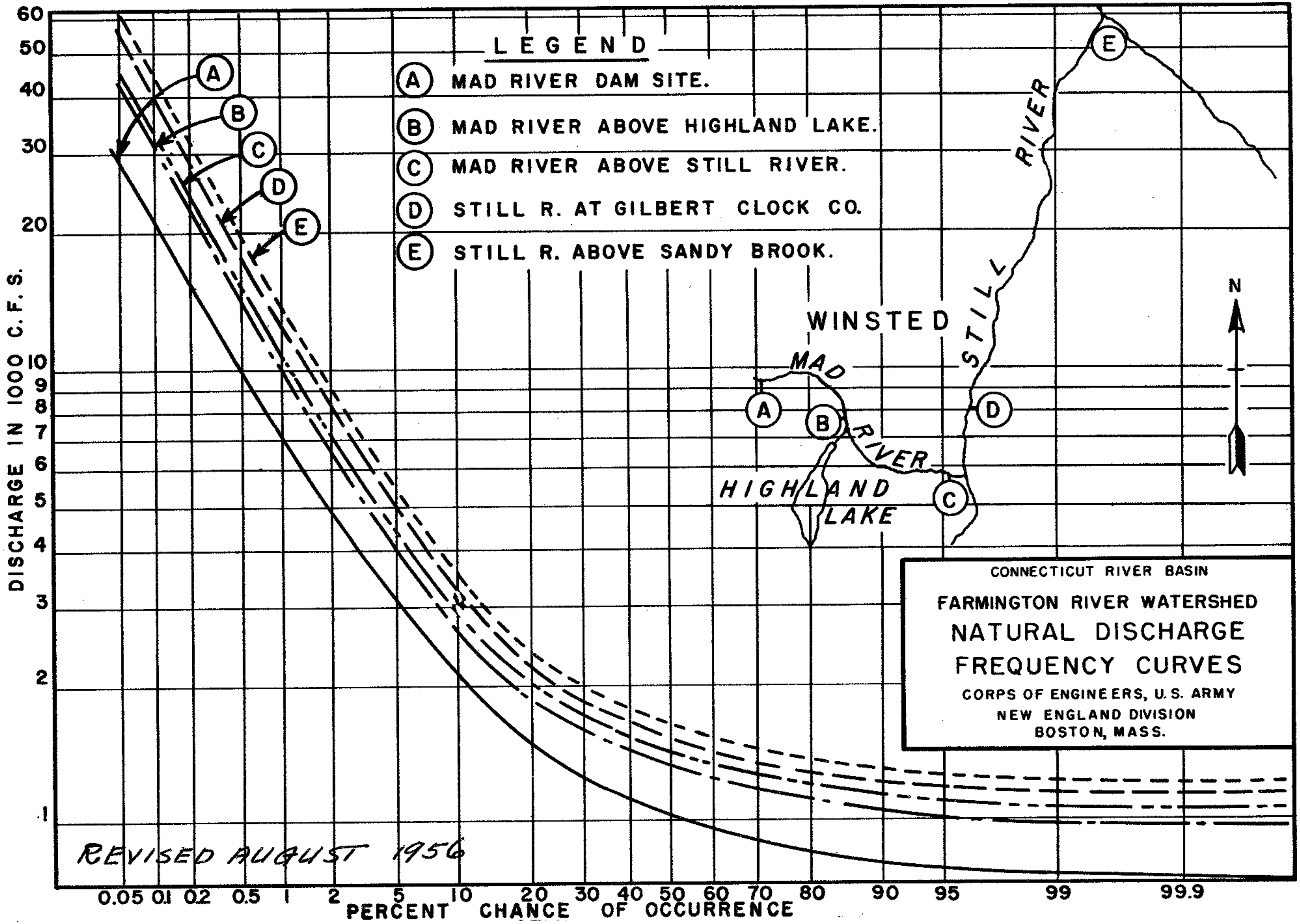
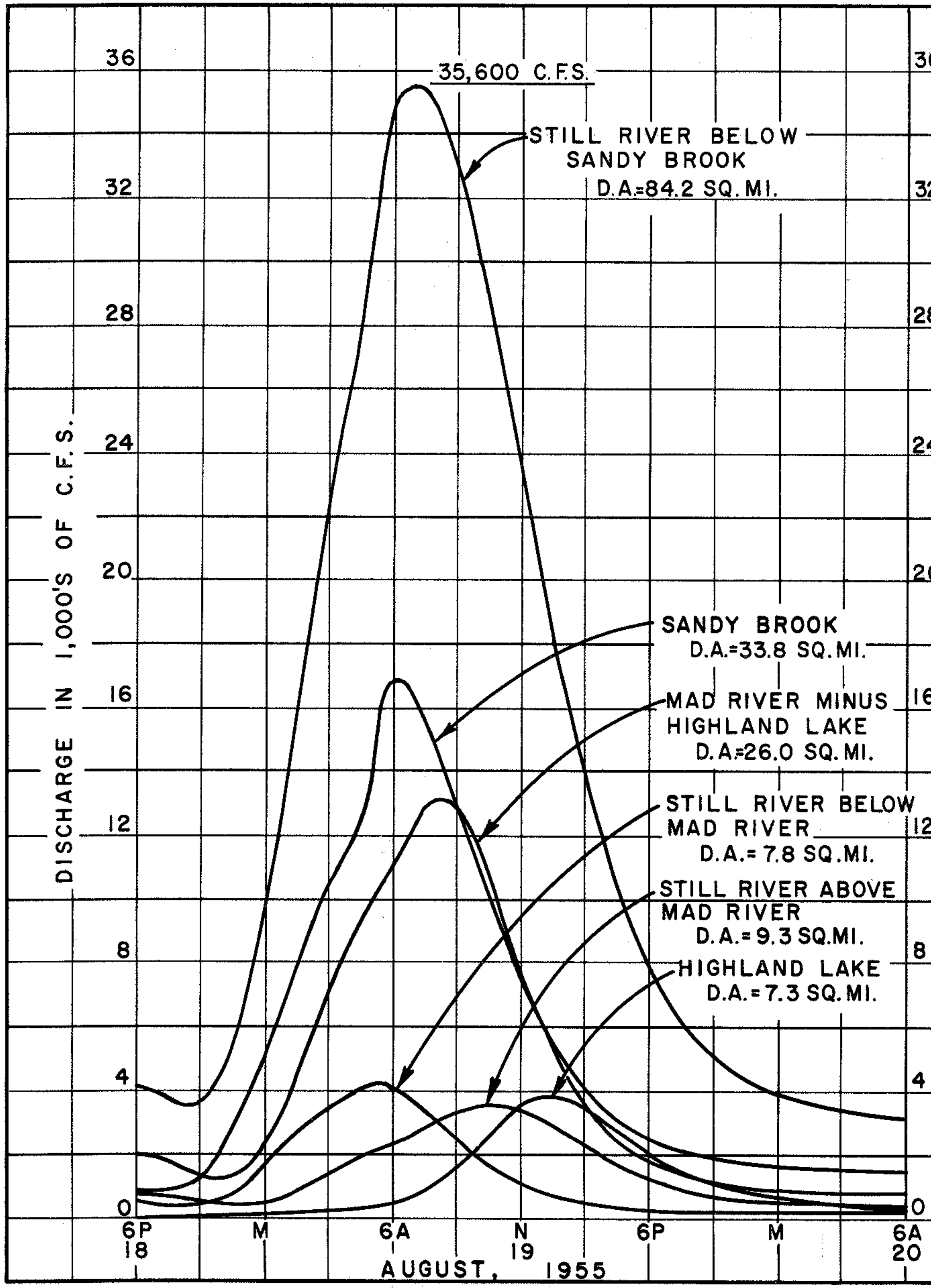
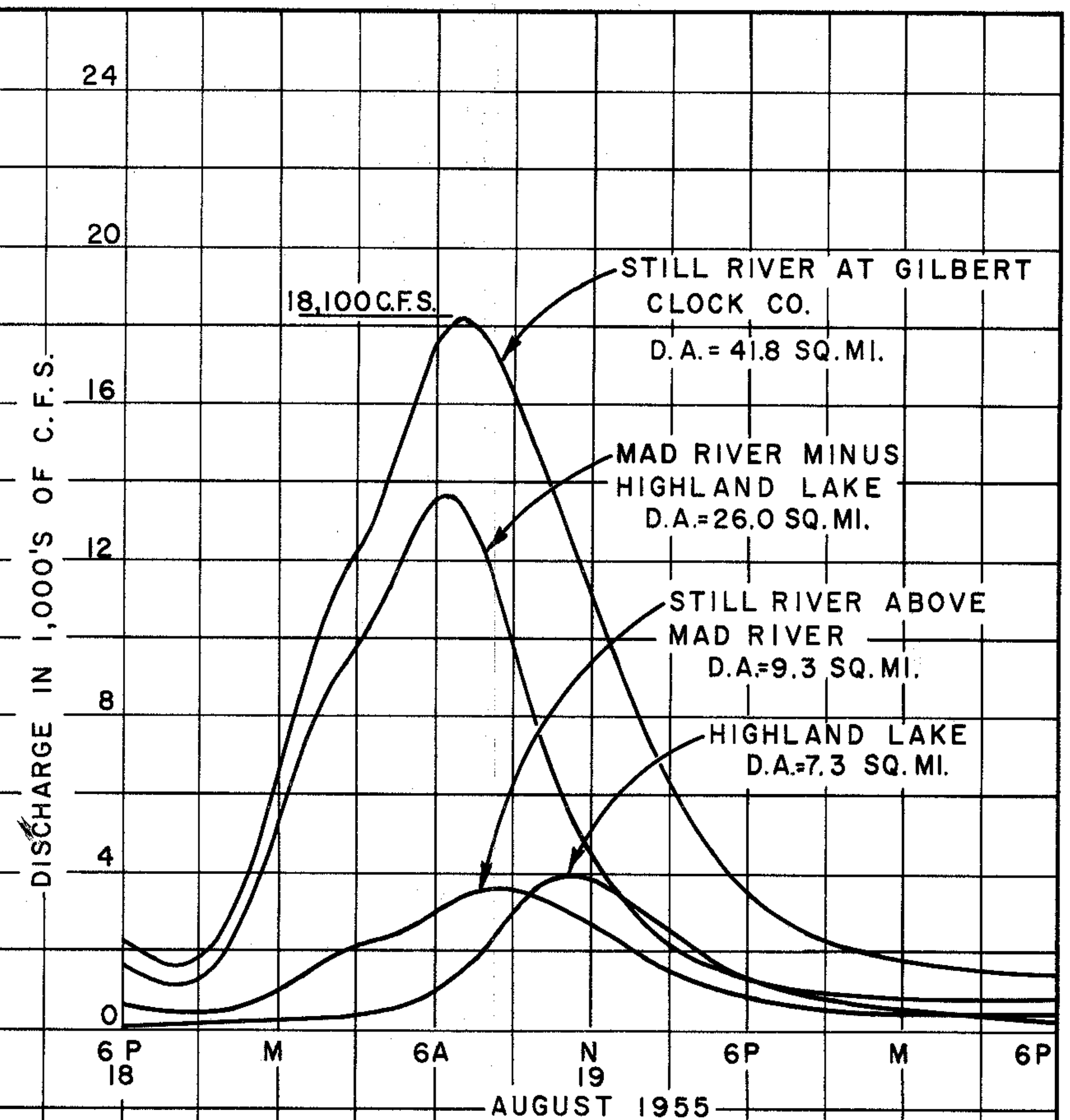

LEGEND
A MAD RIVER DAM SITE.
B MAD RIVER ABOVE HIGHLAND LAKE.
C MAD RIVER ABOVE STILL RIVER.
D STILL R. AT GILBERT CLOCK CO.
E STILL R. ABOVE SANDY BROOK.
WINSTED
MAD RIVER
STILL RIVER
HIGHLAND LAKE
N
DISCHARGE IN 1000 C.F.S.
60
50
40
30
20
10
9
8
7
6
5
4
3
2
.1
PERCENT CHANCE OF OCCURRENCE
0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 99 99.9
REVISED AUGUST 1956
CONNECTICUT RIVER BASIN
FARMINGTON RIVER WATERSHED
NATURAL DISCHARGE
FREQUENCY CURVES
CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-1





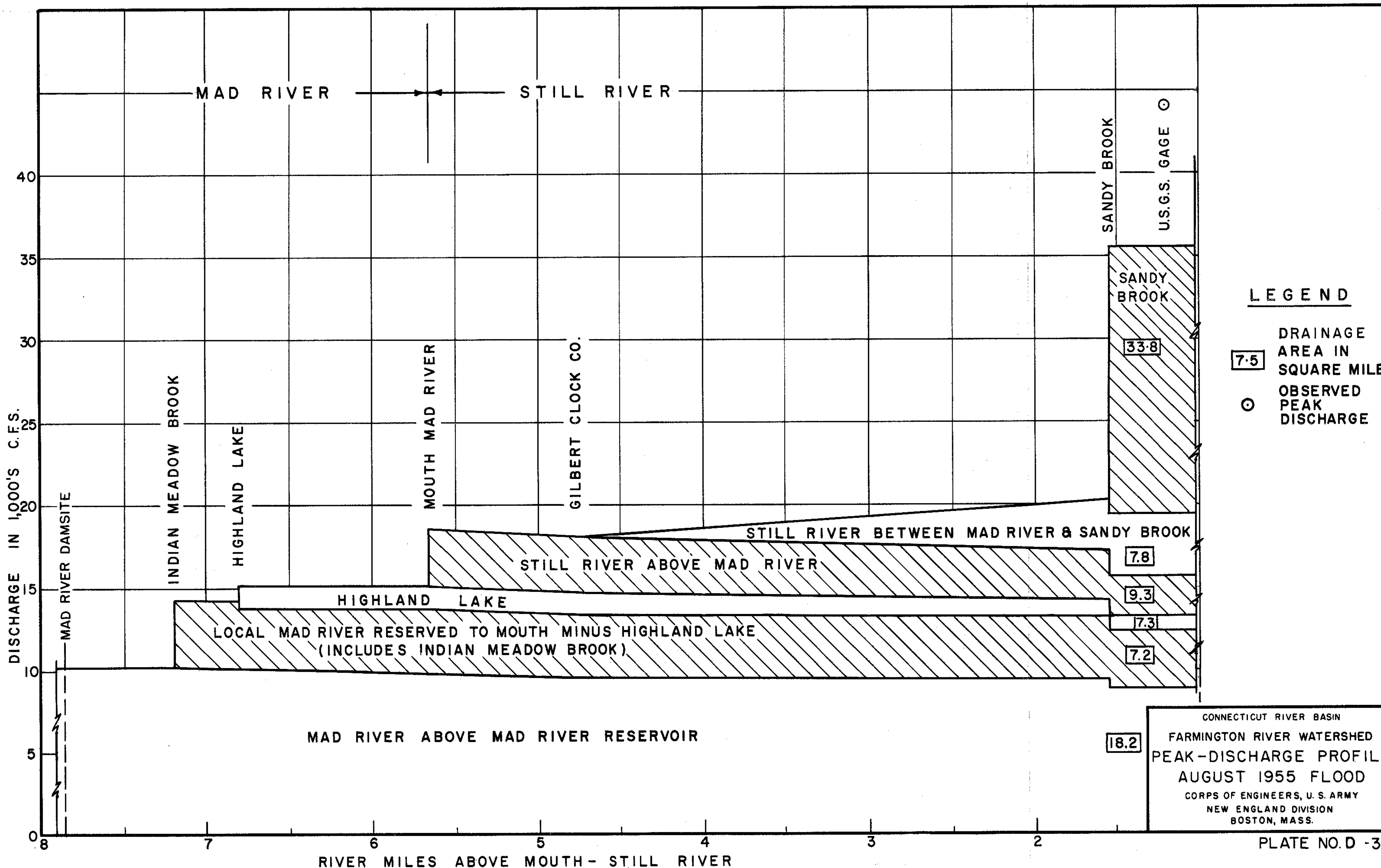
CONNECTICUT RIVER BASIN

FARMINGTON RIVER WATERSHED

TRIBUTARY COMPONENTS FOR AUGUST 1955 FLOOD

CORPS OF ENGINEERS, U. S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-2



CONNECTICUT RIVER BASIN

FARMINGTON RIVER WATERSHED

PEAK-DISCHARGE PROFILE

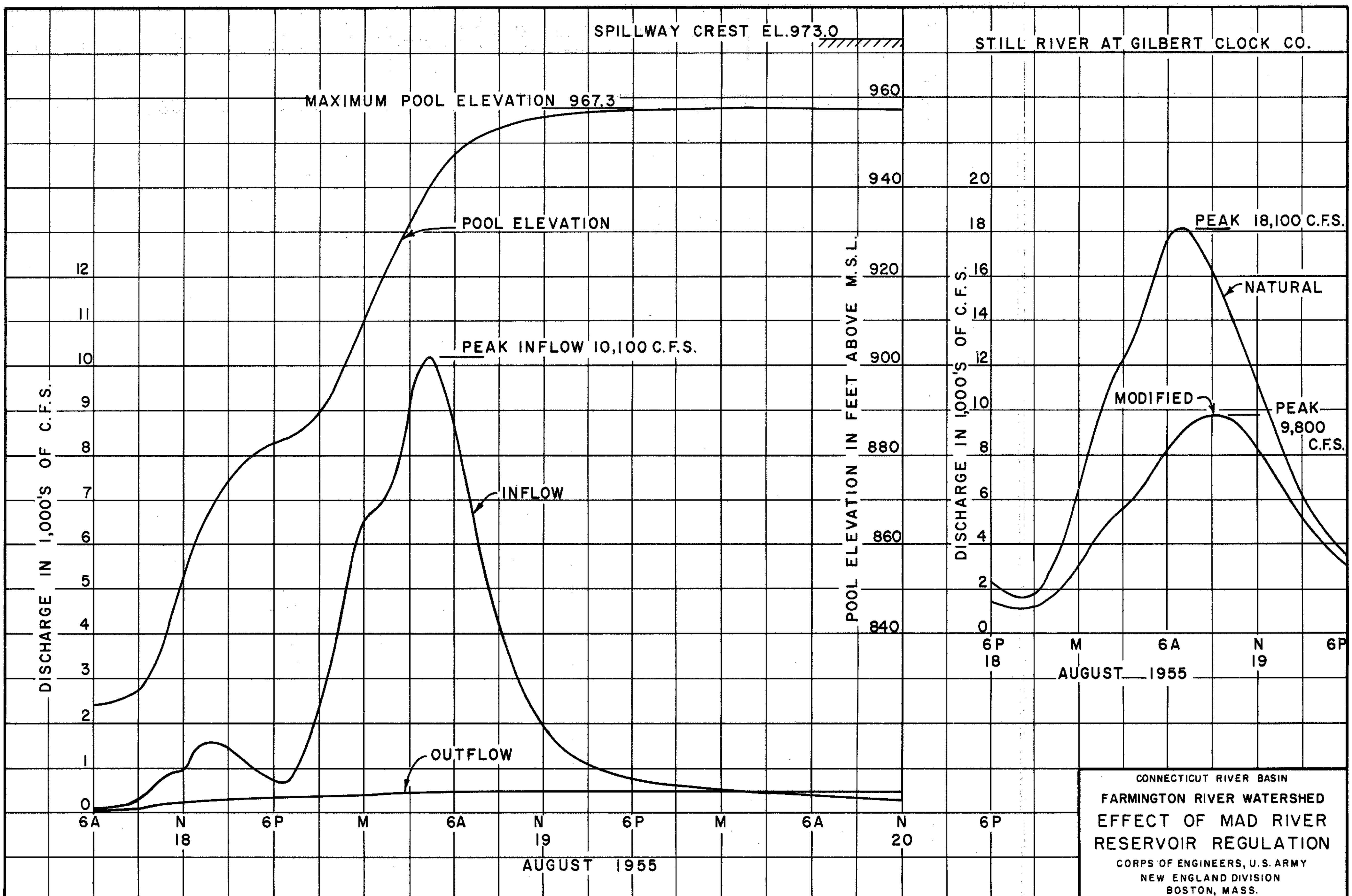
AUGUST 1955 FLOOD

CORPS OF ENGINEERS, U. S. ARMY

NEW ENGLAND DIVISION

BOSTON, MASS.

PLATE NO. D -3



CONNECTICUT RIVER BASIN

FARMINGTON RIVER WATERSHED

EFFECT OF MAD RIVER RESERVOIR REGULATION

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-4

APPENDIX E

DESIGN AND ESTIMATE OF COST

APPENDIX E

DESIGN AND ESTIMATE OF COST

TABLE OF CONTENTS

APPENDIX E

DESIGN AND ESTIMATE OF COST

E1. SURVEYS AND EXPLORATIONS

A topographic map of the dam site (10-foot contour interval) was compiled from U.S.Geological Survey and U.S.Army Map Service sheets (Plate E-1). Topographic data was checked in the field. The principal geologic features were determined by core borings. A knowledge of soil conditions was obtained by field inspections and by investigations of samples in the New England Division Soils Laboratory. Details of geologic and soils investigations and the results of laboratory tests for each site with data on available construction materials are given in Appendix A. Hydrologic and hydraulic data and details are contained in Appendix D.

E2. DETAILS OF DAM AND RESERVOIR

E2.1 Dam and Appurtenant Works. - A rolled-earth dam would be constructed across the main channel of the Mad River. Two earth dikes would also be constructed across saddles on the left bank, north of the dam. A side-channel spillway would be located on the left bank or north end of the dam, and the spillway channel would flow directly into the Mad River. The outlet would discharge into the main channel of the Mad River below the dam. A general plan and typical sections of the dam and appurtenant structures are shown on Plate E-2.

Construction of the dam would necessitate the relocation of U. S. Route 44 for a length of 2.3 miles. The relocation would begin at a point about 0.5 mile downstream from and rejoin Route 44 upstream from the dam site.

E2.2 Plan of Construction. - During the first construction season Route 44 would be relocated and the outlet works constructed. The river would be diverted early in the second season. The spillway-channel excavation and dam-embankment work would then be accomplished concurrently, followed by placing of spillway concrete. It is estimated that all work would be completed in two seasons.

Pertinent Data

Dam	
Type	rolled earth
Top elevation	988 m.s.l.
Length	1,040 feet
Maximum height	168 "
Freeboard above spillway design flood	2.8 "
Dike 1	
Type	rolled earth
Top elevation	988 m.s.l.
Length	750 feet
Maximum height	25 "
Dike 2	
Type	rolled earth
Top elevation	750 feet
Length	1,350 "
Maximum height	50 "

Reservoir	
Spillway crest elevation	973 m.s.l.
Flood-storage capacity at spillway crest	9,630 acre-feet (equal to 10 inches of runoff)
Area (approx.)	180 acres
Spillway	
Type	ogee
Crest elevation	973 m.s.l.
Length	250 feet
Surcharge	12 "
Outlet	
Type	48-inch ungated concrete conduit

E3. COST ESTIMATES

E3.1 Basis of Estimates. - The cost of the dam has been estimated on the basis of a design which would provide an economical and safe structure for the given conditions. Estimates of quantities have been estimated on the basis of net outlines of the proposed design and foundation requirements. Earth-borrow items include stripping the borrow area, spoil, compactions in fill, and shrinkage of borrow. In determining rock quantities, consideration was given to rock available from the required excavation, to spoil, and to a swell factor from excavation to fill.

E3.2 Unit Prices. - Unit prices are based on an average of bid prices, adjusted to 1956 price levels, for similar types of projects constructed, under construction, or under contract in New England. The unit prices adopted are adjusted to include numerous minor items of work which do not appear in the cost estimate.

E3.3 Contingencies, Engineering, and Overhead. - To cover contingencies, construction costs have been increased by 20 percent. The costs of engineering and overhead for the project are estimated lump sums based on knowledge of the site and experience on similar projects.

E3.4 Land and Right-of-Way Costs. - Land requirements would include dam site, borrow, spoil, and reservoir area and land required for road relocation. Reservoir land easements will be to 5 feet above spillway elevation where this is practicable. The costs of rights-of-way and damages have been estimated upon the basis of assessed values, field reconnaissance, and information from local officials.

E3.5 Relocation. - The relocation of U.S. Route 44 would conform as nearly as possible to the standards and requirements of the Connecticut State Highway Department and of other interested agencies. The estimate is adequate to provide for reasonable modification in the plans. Contingencies have been estimated at 20 percent.

E3.6 Basis of Annual Charges. - The estimate for annual charges was prepared on the basis of 2.5 percent interest on the total investment plus amortization of the investment over a period of 50 years. The Federal investment includes the first cost plus 2.5 percent interest for one-half the estimated construction period of 2 years. Loss of taxes (a non-Federal annual charge) is net loss on land taxes. Maintenance of the project is based on knowledge of the site and of similar projects and is included as a non-Federal charge.

E3.7 Cost Estimates. - Federal and non-Federal first costs of the Mad River Dam and Reservoir are detailed in Table E-I below. Annual charges are given in Table I of the main report.

TABLE E-I - MAD RIVER DAM AND RESERVOIR

FIRST COSTS
(1956 Price Level)

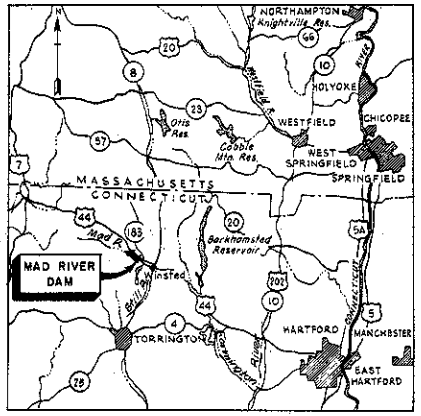
	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Federal First Cost					
		RELOCATIONS			
Roads	2.3	Mile	L.S.	$ 795,000	
Contingencies				159,000	
Total					$ 954,000
		RESERVOIR			
Reservoir Clearing	10	Acre	$350.00	$ 3,500	
Contingencies				500	
Total					4,000
		ACCESS ROAD			
Access Road			L.S.	$ 10,000	
Contingencies				2,000	
Total					12,000
		DAM CONSTRUCTION			
Preparation of Site	19	Acre	$600.00	$ 11,000	
Stream Control	1	Job	L.S.	8,000	
Earth Excavation (Common)	82,000	c.y.	0.60	49,000	
Earth Excavation (Borrow)	1,260,000	c.y.	1.00	1,260,000	
Rock Excavation	134,300	c.y.	3.50	470,000	
Embankment, Rolled	1,116,000	c.y.	0.30	335,000	

FIRST COSTS (Cont.)

	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
DAM CONSTRUCTION (Cont.)					
Filter Sand and Gravel	13,400	c.y.	3.00	$ 40,000	
Rock Fill	115,000	c.y.	0.80	92,000	
Concrete	10,000	c.y.	35.00	350,000	
Conduit	1	Job	L.S.	150,000	
Miscellaneous Items				275,000	
Subtotal				$3,040,000	
Contingencies				610,000	
Total					$3,650,000
Engineering and Design					440,000
Supervision and Inspection					370,000
Total Federal First Cost					$5,430,000

Non-Federal First Cost

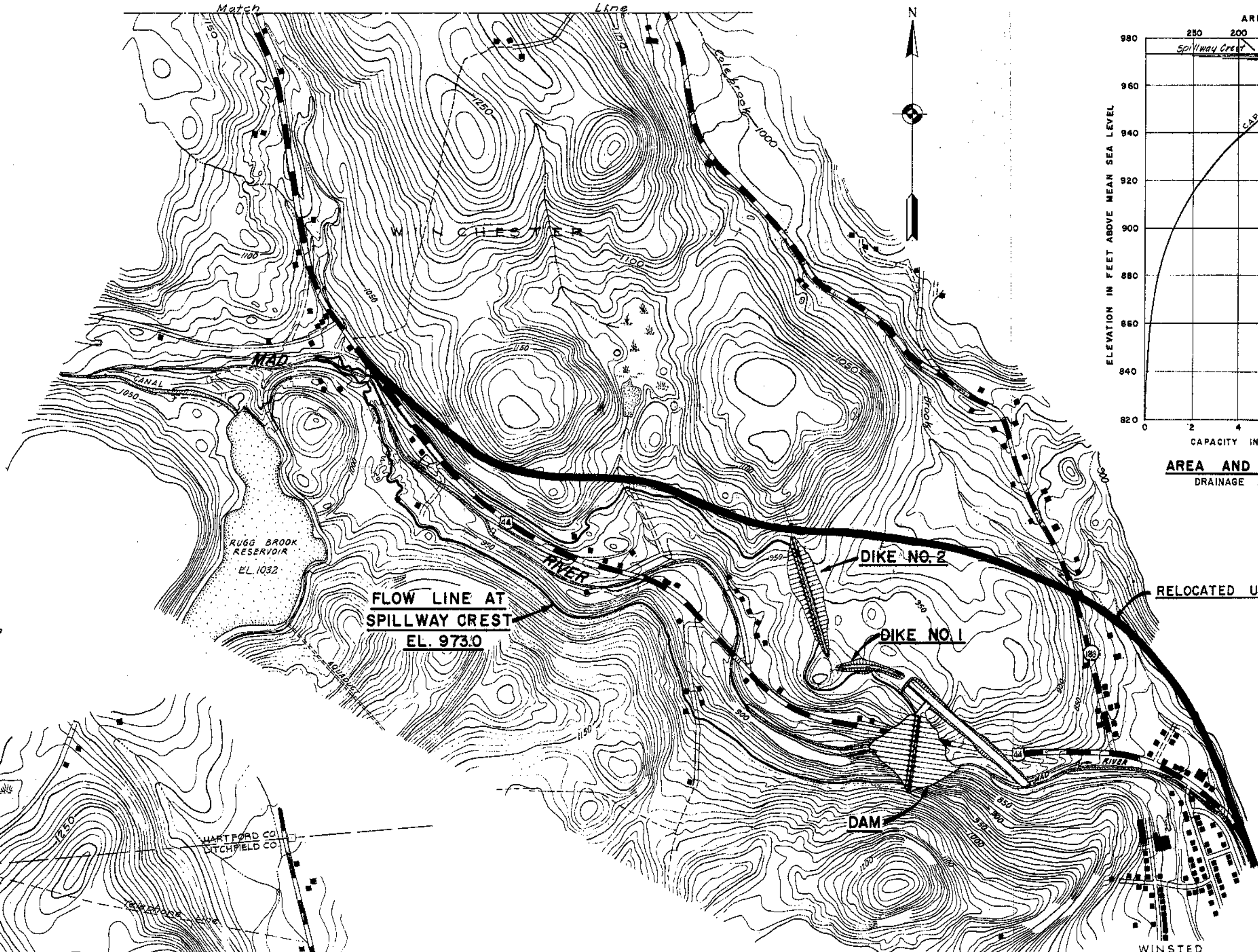
	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
LANDS AND DAMAGES					
Lands			L.S.	$ 50,000	
Improvements Acquired			L.S.	236,000	
Severance Damages			L.S.	30,000	
Subtotal				$ 316,000	
Contingencies				30,000	
Subtotal				$ 346,000	
Resettlement Costs			L.S.	10,000	
Acquisition Costs			L.S.	34,000	
Total Non-Federal First Cost					$ 390,000
Total Project First Cost					$5,820,000

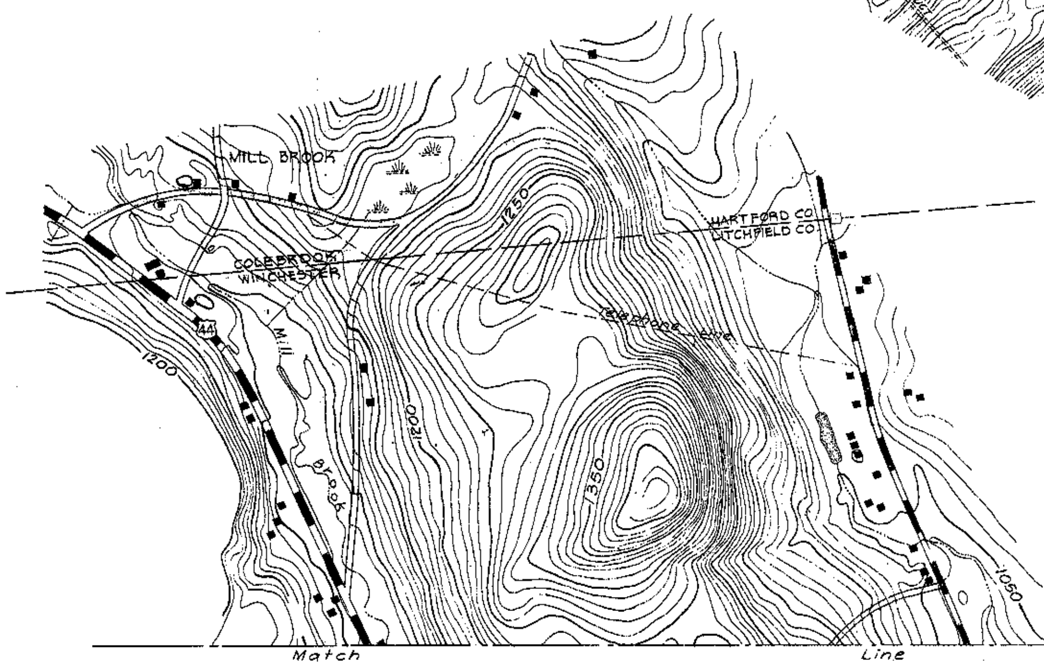


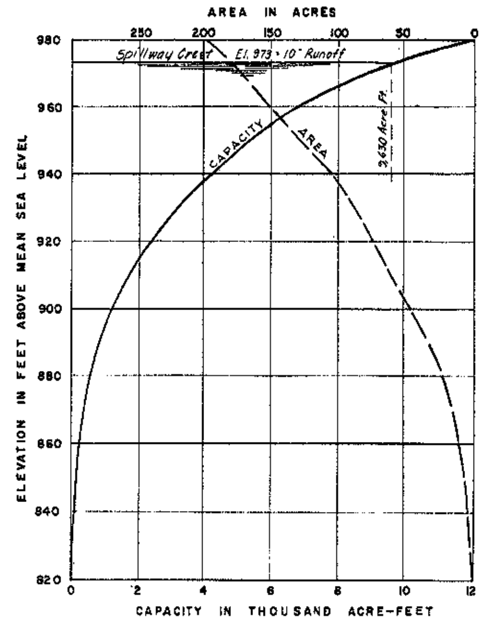
VICINITY MAP

SCALE IN MILES

5 0 5 10 15 20







AREA AND CAPACITY CURVES

DRAINAGE AREA 18.2 SQ. MILES

LEGEND

- Existing gravel roads
- Surfaced Town roads
- Reservoir at spillway crest, EL 973
- Relocated highway
- State and Federal highways
- Civil Township line

RESERVOIR PLAN

SCALE IN FEET

0 500' 1000' 1500'

NOTES

Elevations refer to Mean Sea Level Datum
Contour interval equals ten feet
Topography is based on U. S. G. S. and Army Map Service Maps.

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NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
LB	BG	HEB

CONNECTICUT RIVER FLOOD CONTROL

MAD RIVER DAM

RESERVOIR MAP

MAD RIVER CONNECTICUT

Alva J. Armstrong
PROJECT ENGINEER

SUBMITTED BY:
CHIEF, PLANN. & RPTS BRANCH

APPROVED:
CHIEF ENGINEERING DIV

APPROVED:
LT. COL., C.E., ASST. TO DIVISION ENGINEER

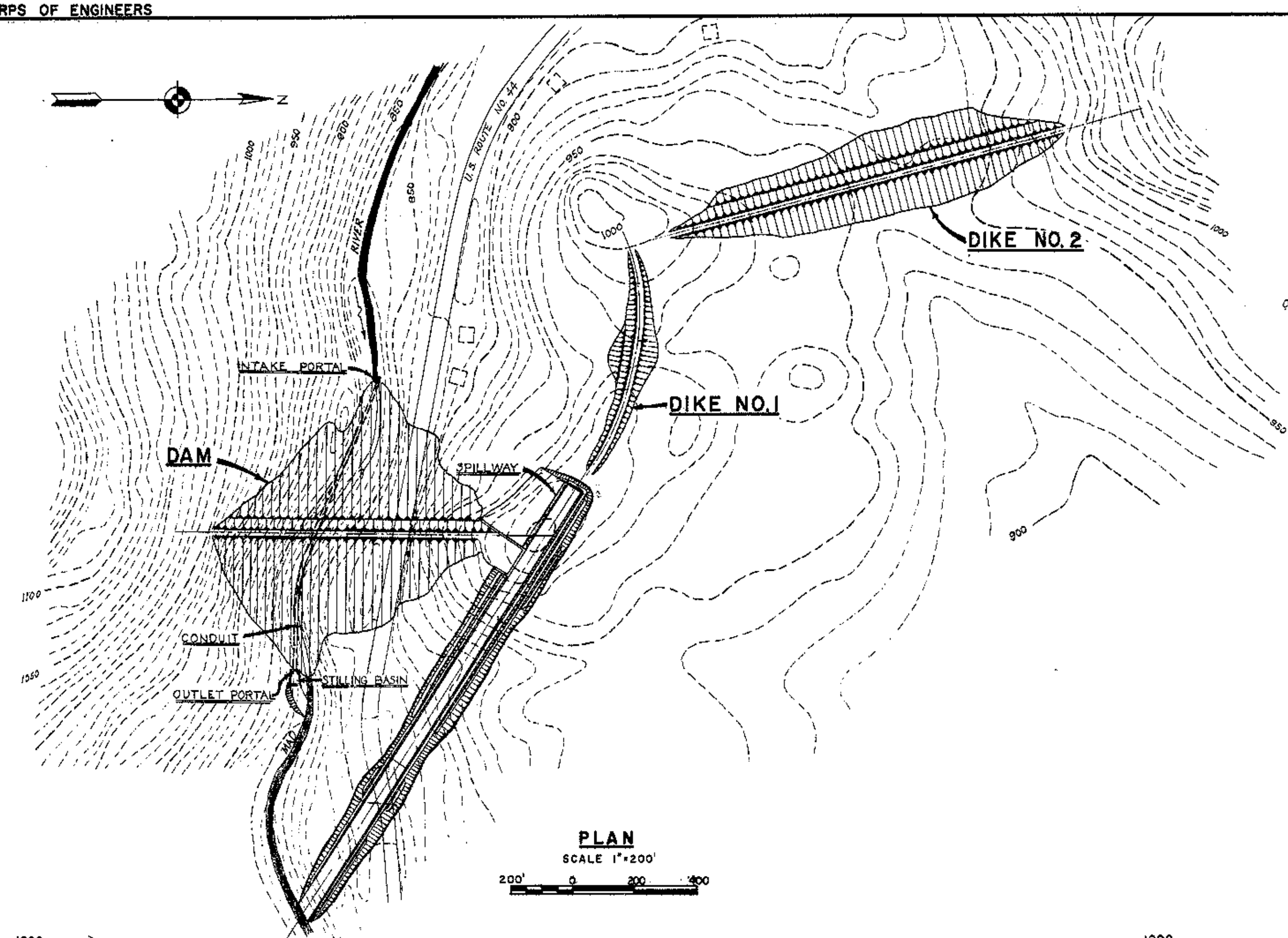
DATE JUNE 1956

SCALE: AS SHOWN

TO ACCOMPANY REPORT DATED 14 JUNE 1956

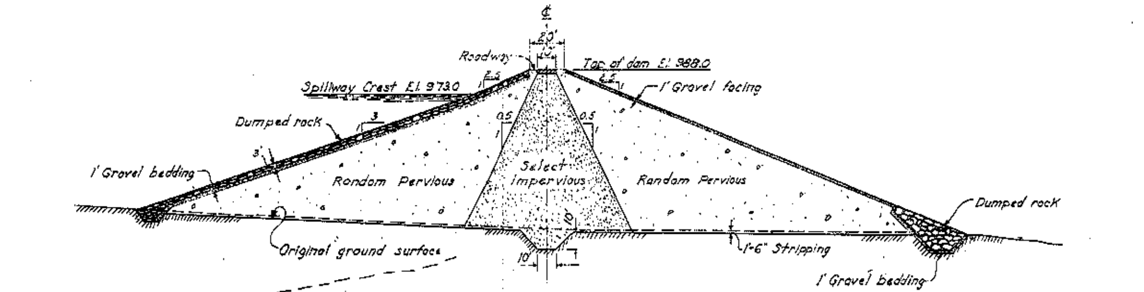
DRAWING NUMBER CT-1-4084

SHEET 1 OF 2



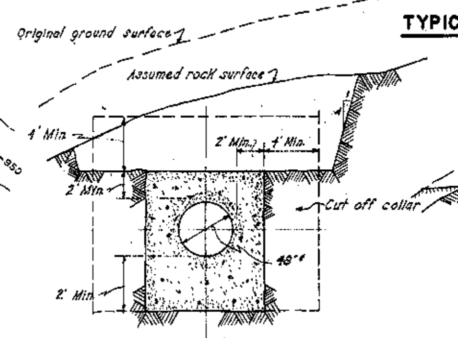
PLAN

SCALE 1" = 200'



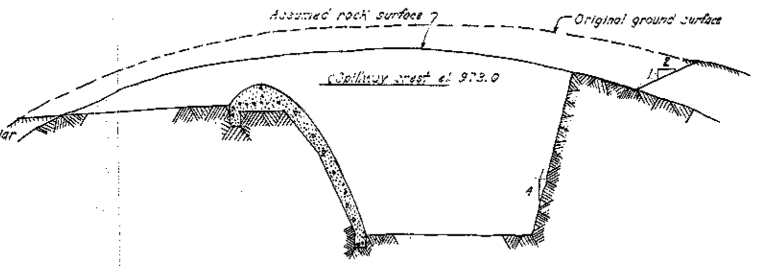
TYPICAL DAM & DIKE SECTION

SCALE 1" = 40'



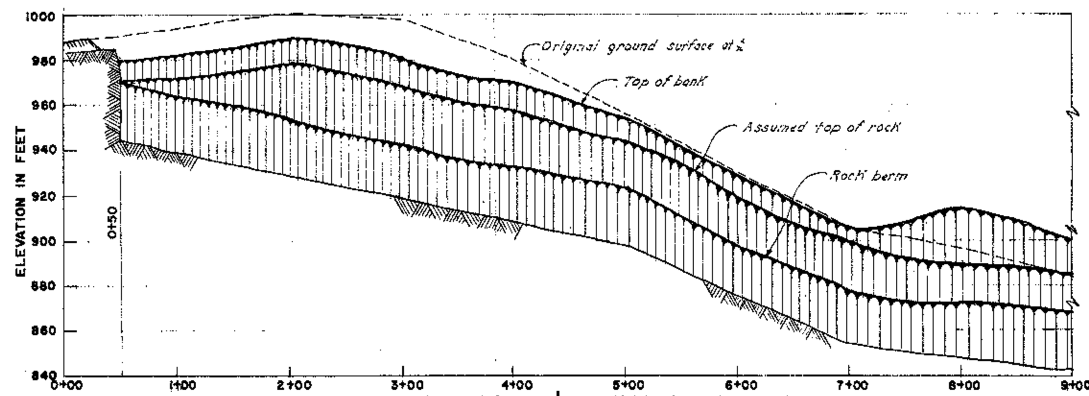
SECTION THRU CONDUIT IN ROCK

SCALE 1" = 5'



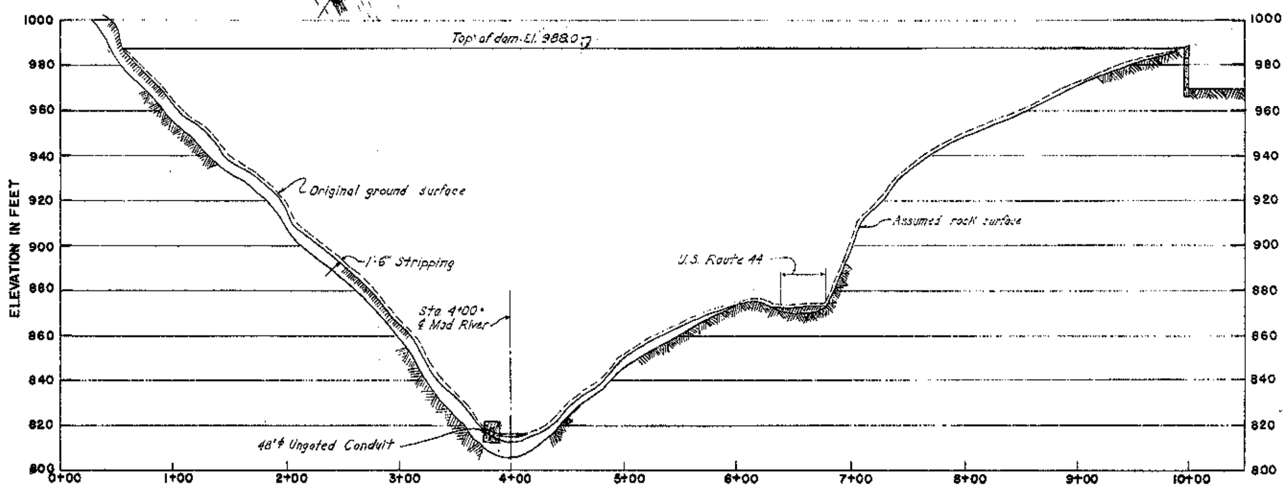
SECTION THRU SPILLWAY

SCALE 1" = 20'



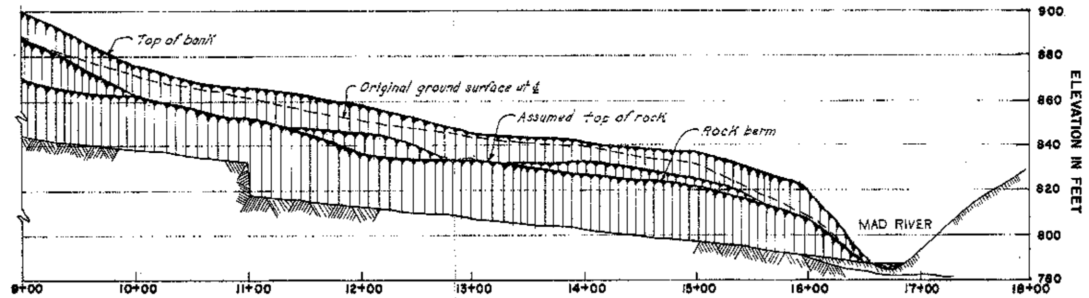
PROFILE ALONG ℄ SPILLWAY CHANNEL

SCALE HOR. 1" = 60' VERT. 1" = 30'

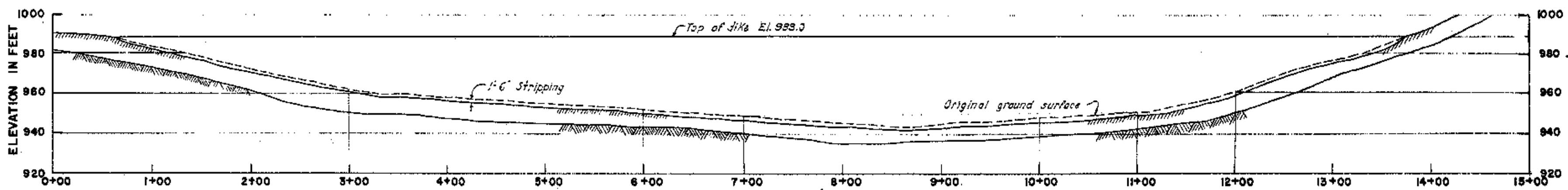


PROFILE ALONG ℄ DAM

SCALE HOR. 1" = 60' VERT. 1" = 30'



PROFILE (CONTINUED)



PROFILE ALONG ℄ DIKE NO. 2

SCALE HOR. 1" = 60' VERT. 1" = 30'

NOTES

Elevations refer to Mean Sea Level Datum.

Contour interval equals ten feet.

Topography is based on U.S.G.S. and Army Map Service Maps.

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BOSTON, MASS.

DR. BY	TR. BY	CK. BY
L.B.	L.B.	H.E.B.

Alex J. Armstrong
PROJECT ENGINEER

SUBMITTED BY:
CHIEF, PLANN. & RPTS BRANCH

APPROVED:
CHIEF, ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL

MAD RIVER DAM

GENERAL PLAN

MAD RIVER CONNECTICUT

APPROVED:
LT. COL., C.E., ASST. TO DIVISION ENGINEER

DATE JUNE 1956

SCALE: AS SHOWN

TO ACCOMPANY REPORT DATED 14 JUNE 1956

DRAWING NUMBER CT-1-4085

SHEET 2 OF 2

PLATE NO. E-2